NEWARK, N. J.

PRACTICAL ENGINEER

Trade-mark reg. U. S. Pat. Office.

VOL. XVI CHICAGO, NOVEMBER 15, 1912 No. 22

POWER EQUIPMENT OF A TYPEWRITER FACTORY

Combination Steam Turbine Equipment and Niagara Falls Power, Operating the Electrically Driven Machinery in the Factories of the L. C. Smith & Bros. Typewriter Co. at Syracuse, N. Y.

CLICKETY CLICK CLICK, the merry hum of many typewriters, was the sound that met the ears of the writer on a recent visit to the works of the L. C. Smith & Bros. Typewriter Co., at Syracuse, N. Y., consisting of 8-story buildings, covering nearly a city block. This sound was not particularly attractive, as it was the power plant farther back in another building that was the center of interest.

But wait! When one of the officials made the remark that a man interested in power plants should surely be interested in bearings of all kinds, especially ball bearings, it naturally made a fellow sit up and take notice, and herein lies a little tale that may be of interest, before we make inspection of not "the power behind the throne," but the power behind the many wonderful machines, that prepare the parts of the smallest ball bearings ever made, many of which are used in every typewriter turned out from this establishment.

There are 15 steel balls in the bearing of every type-bar, that is, the little bar holding each piece of type of this writing machine, and in round numbers, 75,000 to 100,000 of such balls are used daily by the type assemblers in this factory. A ball-making plant was established to turn out more perfect balls than anyone else in the world has ever made. This involved designing and manufacture of tools and machinery at a cost of thousands of dollars, but within a short time a plant with a capacity of over 100,000 steel balls per day, for transforming the rough rods of steel into beautifully polished, hardened, perfect spheres was constructed and set in operation.

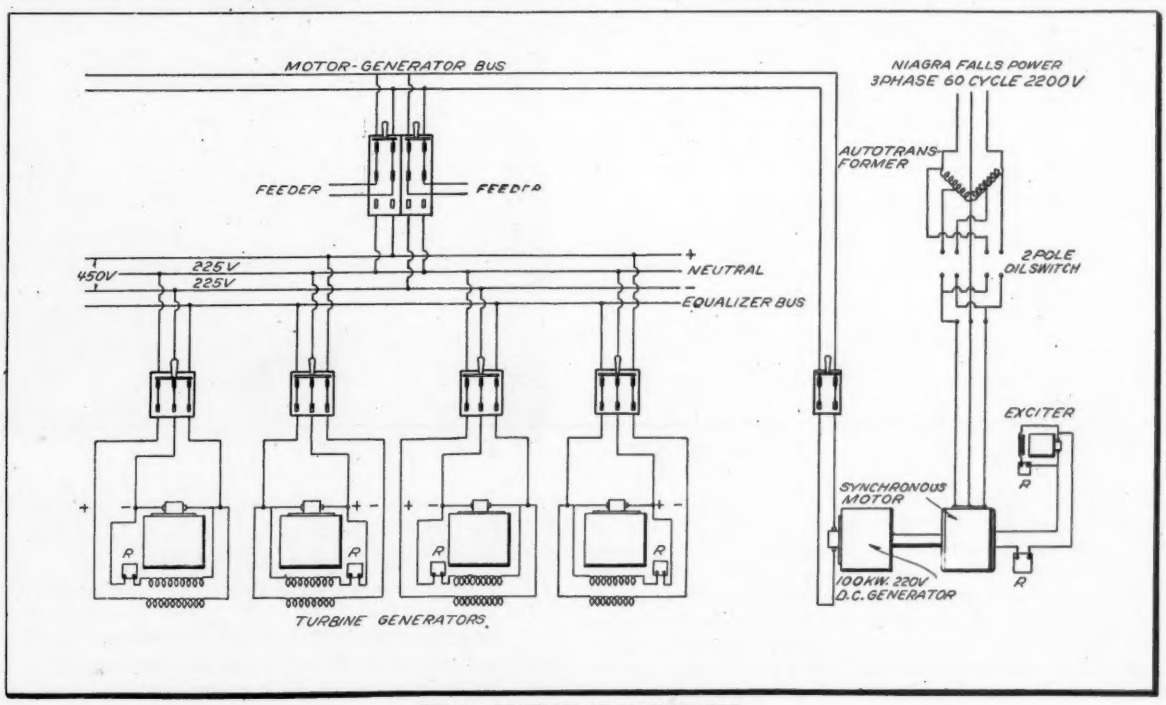

FIG. 3. DIAGRAM OF CONNECTIONS

The balls, after being made, hardened and polished, are automatically graded to size by an ingenious device designed and made in the factory. The ball-bearings are capable of much closer adjustment without friction than the ordinary pinion bearings, and being as nearly frictionless as it is possible for any mechanism to be made, they do not wear loose and consequently retain their adjustment indefinitely.

Well, so much for the ball-bearings. We will now seek the engine room where bearings of more liberal proportion are merrily humming in their bath of oil. The city of Syracuse uses a great deal of Niagara Falls power, coming from its source nearly 150 miles away, and the plant of the L. C. Smith & Bros. Typewriter Co., is a combination of this power and a turbine steam plant. It really gives one an uncanny feeling to watch wheels revolve and know that the power is being generated amidst the roar of old Niagara so far distant.

Electric motor drive is used throughout the works, and in all about 25 direct-current motors are in operation, adding to the cleanliness and lighting facilities. The absence of shafting and belting with its attendant noise and dirt is a noticeable feature of this plant.

General Arrangement

THE power house is located in an area between the angles of the main buildings shown in Fig. 4, and is a substantial brick building divided into 2 parts, the boiler room and the engine room. In the boiler room, besides the boilers, are located the boiler feed pumps and feed-water heater. In the engine room are 2 turbine generating units and a motor-generator set for transforming Niagara power to direct current at 220 volts. The home-made power and that from Niagara are connected to the same switchboard and by means of double-throw switches either can be used. Here one imagines he can see Syracuse and Niagara Falls shaking hands.

Boilers

EQUIPMENT of boilers consists of 3 Heine water-tube boilers rated at 153 hp. each, resting on foundations 18 ft. 6 in. long and 7 ft. 6 in. wide. They are hand-

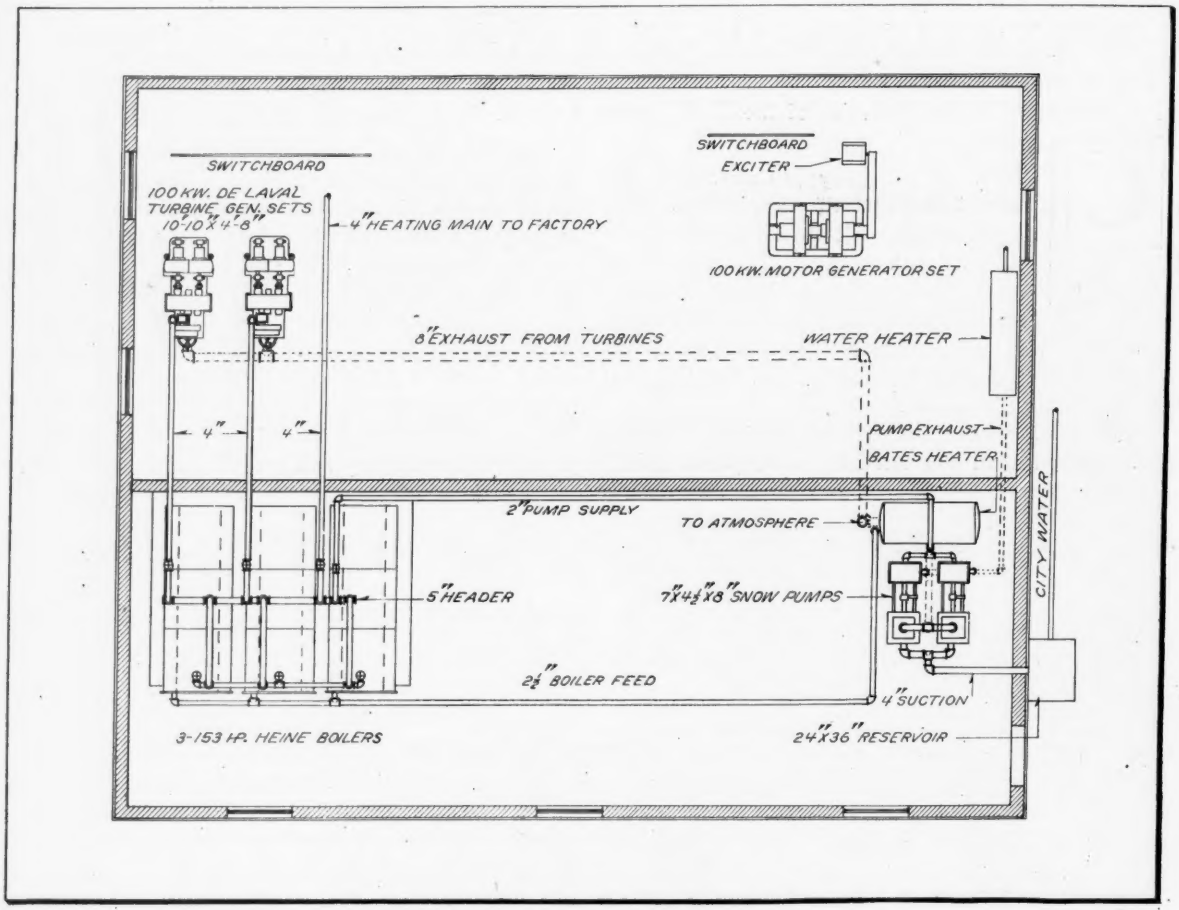

FIG. 1. GENERAL LAY-OUT OF POWER PLANT

fired, using anthracite dust and bituminous coal mixed, coal being hauled in wagons and deposited on a concrete floored storage place in front of the boilers.

Each boiler has 1530 sq. ft. of heating surface; the grates are 5 ft. 5 in. wide by 7 ft. long and contain 38 sq. ft. of grate area. Each boiler is provided with one steam and one water drum, 36 in. in diameter, by 19 ft. long, which is made of ⅜-in. plate with heads ⅝ in. thick; the water legs are made of flanged steel plate ½ in. thick. The main steam outlets are 5 in. in diameter, and each boiler is equipped with the following auxiliary apparatus: One 3-in. Ashton nickel seated pop safety valve set at 150 lb. pressure; an 18-in. Standard steam gage; 2 1½-in. Cadman blowoff valves; a 1½-in. Crane

feed-water valve; a 1½-in. Pratt & Cady check valve; a Reliance water column with 3 gage cocks, and 1 quick cleaning water gage.

Tensile strength of the boilers is guaranteed to be from 57,000 to 64,000 lb., and the elastic limit 32,000 lb. to the sq. in. There are in each boiler, 96 tubes, 15 ft. long and 3½ in. in diameter.

Feed Water

FEED water is taken from the city mains and it flows into a storage tank 2 ft. by 3 ft. outside of the power house. It is then forced into the boilers through a B. T. Bates heater by either one of 2 Snow pumps 7 by 4½ by 8 in., exhaust from the pump being utilized in a small heater for heating wash water.

Piping

IN each steam outlet of the boiler is a valve from which a 5-in. steam pipe leads to a 5-in. header; from the header to each turbine is a 4-in. steam pipe with a valve located near the header and a throttle valve at the machine. A 4-in steam main for building heating purpose crosses the engine room from the header to the factory where a reducing valve is introduced. Condensation from the radiator flows to a trap by gravity and is returned to the boilers. The exhaust main is run from

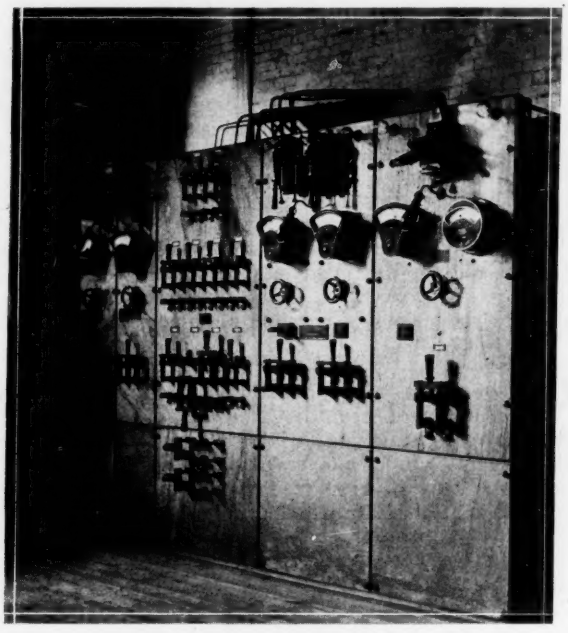

FIG. 2. MAIN SWITCHBOARD

the turbine to the heater and then discharges into the atmosphere. The boilers are fed by 2½-in. pipe provided with a valve for each boiler. All piping is covered with magnesia sectional pipe covering.

Engine Room Equipment

GENERATING units consist of 2 De Laval, self-contained direct-current turbine generating sets, rated at 150 brake hp. or 100 kw., the speed being 1200 r.p.m., operating at 140 lb. boiler pressure. Two generators are mounted side by side and geared together by means of a turbine pinion and 2 gears.

Owing to the short distance between shaft centers it is possible to combine what would otherwise be 2 separate generator frames into one, at the same time leaving 2 openings in which the armatures revolve. The generators are rated at 444 amp. and 225 volts for a 2-wire and 222 amp. and 450 volts for a 3-wire system.

Dimensions of each unit are 10 ft. 10 in. long by 4 ft. 8 in. wide, and the weight is approximately 16,000 lb. each. The diameter of the steam pipe is 4 in., and that leading to each unit is equipped with a Sweet separator. The exhaust pipe is 8 in. in diameter.

Main shaft and generator bearings are ring oiling, but the turbine shafts are fed from a common reservoir

FIG. 4. FACTORY OF L. C. SMITH & BROS. TYPEWRITER CO.

holding enough oil for a day's run, the drippings from which collect in a reservoir. The interior of the turbine or the mechanism is lubricated by sight feed lubricators.

Motor-Generator Set

NIAGARA Falls power supplements the generating units, alternating current of 2200 volts supplying a motor-generating set of 100 kw. capacity, high tension current being supplied by the Syracuse Lighting Co., through a sub-station. The motor-generator set consists of a Crocker-Wheeler 2200-volt, 3-phase, synchronous motor, operating at 900 r.p.m., direct coupled on the same base to a Crocker-Wheeler d.c. generator rated at 100 kw., 250 volts and 400 amp. A 125-volt, 22-amp. exciter for the synchronous motor is belted to the shaft extension on the synchronous motor end.

Motor-Generator Switchboard

CURRENT at 2200 volts for supplying the motor-generator set enters a special switchboard which stands nearby; it consists of a large panel on which are mounted in a row near the top a Weston ammeter, Westinghouse polyphase integrating wattmeter and a Westinghouse power factor meter.

Directly beneath the integrating wattmeter is a Westinghouse graphic recording wattmeter. At the lower left-hand corner of the panel is the operating handle of the incoming oil switch and at the lower righthand side is a double oil starting switch connected to an auto-transformer mounted above the board for starting the synchronous motor of the motor-generator set. Field rheostats for both the exciter and the direct current generator are mounted on the board.

Entrance for the 2200-volt Niagara current is made through the brick wall adjacent to the board with the high tension fuse mounted on the wall. In a corner near the board is a General Electric, 10-kw. 60-cycle transformer that reduces the voltage from 2200 to 1100 volts for use in an electric spot welder in the factory.

The main switchboard is divided into 5 sections, 2 panels high. The first 2 panels at the left as seen in Fig. 2, and the fourth panel are for controlling the De Laval turbine generators; the fifth panel is for controlling the direct current end of the motor-generator set. The first 2 panels and the fourth panel have similar equipment, which consists of 2 circuit breakers, 2 Thomson astatic ammeters, a triple pole switch and field rheostats. The third panel is for feeders and contains 12 double-pole double-throw switches, so arranged that by throwing in one direction or the other either power generated in the station or Niagara Falls power can be used. A direct-current motor generator panel contains a circuit breaker, a Thomson astatic ammeter, a Weston voltmeter, field rheostat, and double-pole single-throw switch. Each generator panel is provided with a voltmeter switch, the voltage being read by the voltmeter on the motor generator board. Fig. 3 is a diagram of the wiring and connections in the engine room.

DESIGN OF STEAM PIPING SYSTEM

Determining Size of Steam Pipes for a Given Rate of Steam Flow

By Wm. F. Fischer

WHEN designing a system of steam piping for a power plant, a great many engineers do not calculate the size of the steam pipes for a given service, but accept the manufacturers sizes and provide piping, valves and fittings to correspond to the pipe connections on the machines. This should not be considered good engineering practice, as piping systems proportioned in this manner are very apt to be much larger and more costly than necessary. In all cases the piping system should be proportioned to suit the actual steam consumption of the different units, allowing a fairly high velocity in the piping system where practical to do so.

Some few years ago it was customary to design steam piping systems for a maximum velocity of, from 4000 to 4500 ft. per minute. In present day practice, owing to a better understanding of conditions and the use of extremely large size turbine and engine units, steam velocities as high as 15,000 ft. per minute are frequently employed, and even higher velocities where the piping is comparatively short and free from sharp bends and elbows, and where large receiver separators are placed next the engine throttle.

TABLE I. SATURATED STEAM TABLES, CONDENSED FROM MARKS & DAVIS TABLES

COL. 1 ABSOLUTE PRESSURE POUNDS PER SQ. INCH	COL. 2 GAGE PRESSURE POUNDS PER SQ. INCH	COL. 3 SPECIFIC VOLUME CUBIC FEET PER POUND OF STEAM=S	COL. 4 DENSITY IN POUNDS PER CUBIC FOOT
75	60.3	5.81	0.1721
85	70.3	5.16	0.1937
95	80.3	4.65	0.2151
105	90.3	4.23	0.2365
115	100.3	3.88	0.2577
125	110.3	3.58	0.2791
135	120.3	3.31	0.3002
145	130.3	3.11	0.3213
155	140.3	2.92	0.3425
165	150.3	2.75	0.3633
175	160.3	2.60	0.3843
185	170.3	2.47	0.4052
195	180.3	2.35	0.4262
205	190.3	2.24	0.447
215	200.3	2.14	0.468
225	210.3	2.05	0.489
235	220.3	1.96	0.509
245	230.3	1.89	0.530
254	239.3	1.82	0.549
264	249.3	1.76	0.569

In large steam turbine work, steam velocities as high as 20,000 ft. per minute are frequently employed in present day practice.

A small pipe and high velocity produces greater friction in the line and a greater pressure drop at the engines, thus causing the steam to give up some of its heat before reaching the engines.

This heat is not wholly wasted, however, as it tends to prevent or counteract the condensation losses in steam lines carrying saturated steam, and adds to the superheat in superheated steam mains. In piping of large diameter the radiating surface is considerably larger than in the smaller size pipe, thus causing greater condensation losses throughout the piping system.

Therefore, in order to cut down radiation and condensation losses and to reduce the cost of the piping system, valves, fittings, etc., to a minimum, the piping from boilers to engines, including the main steam header, should be kept as small as possible without causing too great a drop in pressure at the engines and turbines.

If the pipe sizes are kept too small, however, the friction losses may be so great as to more than offset the economy of the smaller size pipe and the pressure drop at the engines may be such as to interfere with the successful operation of the different units, especially during periods of maximum, or peak loads.

Steam Velocities

ONE of the most important features in the design is the rate of steam flow, or the velocity at which the steam is traveling in the piping system. For the general run of power plant work the following velocities may be employed with good results: 6000 to 8000 ft. per minute for saturated steam, and 8000 to 12,000 ft. per minute for superheated steam.

In large power stations these velocities are very often increased to 14,000 ft. per minute for reciprocating engines, and 15,000 ft. per minute for steam turbine work, for superheated steam, depending upon the design and layout of the piping system, the friction losses and pressure drop. In one of the large central power stations in the Eastern states they carry their steam in certain parts of the piping system at not far from 21,000 ft. per minute for steam turbine work and 15,000 ft. per minute for steam engine work, with no apparent loss of economy.

In the general run of power plant work the main steam header is placed close to the boilers, and the boiler leads, or branch pipes connecting the boilers with main steam header, are short and free from numerous short bends and elbows. As a rule the boilers and engines are so selected that, as the station load changes, certain engines and boilers may be put in, or taken out of service, to suit the demands for power.

In proportioning steam pipes it is advisable to assume the worst conditions and fix the pipe sizes and steam velocities accordingly.

For example: Assume the boilers in a certain plant to be of 450 hp. capacity, normal rating, but subject at times to a 25 per cent overload, over long periods. At 450 hp., each boiler will evaporate approximately 30×450=13,500 lb. of water per hour, and at 25 per cent overload each boiler will evaporate approximately 30×450×1.25=16,875 lb. of water per hour. In this case the boiler leads should be proportioned on a basis of 16,875 lb. of steam per hour as the maximum weight of steam to be conveyed from one point to another.

Determining Area of Pipe for a Given Velocity

A METHOD of determining the area, and pipe size for a given set of conditions may be best illustrated by the following example:

Example 1. What standard size pipe, will be required to convey 16,875 lb. of saturated steam per hour, at 150 lb. gage pressure (friction neglected), and 6000 ft. per minute velocity?

Answer: 5-in. pipe, determined as follows:

16,875÷60=281 lb. of steam per minute. The specific volume of saturated steam at 150 lb. gage pressure is found from, Table I, column 3 to be 2.75 cu. ft. per pound. Therefore 281×2.75=773 cu. ft. of steam will flow through the pipe in one minute, and at a velocity of 6000 ft. per minute, the area of the pipe should be 773÷6000=0.129 sq. ft. Multiplying 0.129 by 144 (the number of square inches to one square foot) we get; 0.129×144=18.54 sq. in. as the area of the pipe for a velocity of 6000 ft. per minute.

Looking in Table II, column 2, we find the nearest size pipe to be a 5-in. standard pipe, having an internal area of 19.98, say 20 square inches.

The actual velocity in the 5-in. pipe for the above conditions, may be found by dividing the volume of steam in cubic feet per minute, by the area of the pipe, in square feet; or

$$773 \div \frac{20}{144} = \frac{773 \times 144}{20} = 5565 \text{ ft. per minute velocity.}$$

As a rule a boiler of the size mentioned above (450 hp.) will have about an 8-in. steam connection, and if the pipe leading from the boiler to the header was made the same size, the velocity in the 8-in. pipe would be 773×144÷50=2226 ft. per minute (50=area of 8-in. pipe). The 8-in. pipe and fittings would cost considerably more than the 5-in. pipe and fittings, and the condensation losses would be greater.

From the above, we get the following rule for area of pipe in square inches—

Area pipe in square inches = Pounds of steam per minute × specific volume × 144, divided by velocity in feet per minute.*

*Expressed as a formula this becomes:

$$A = \frac{144 \times P \times S}{V} \quad \text{Formula 1.}$$

$$V = \frac{144 \times P \times S}{A} \quad \text{Formula 2.}$$

$$P = \frac{A \times V}{144 \times S} \quad \text{Formula 3.}$$

Where A = area of pipe in square inches,
P = The equivalent weight of steam flowing through the pipe in pounds per minute.
S = Specific volume, or cubic feet of steam per pound, at the given pressure (See Table 1 for Saturated Steam).
V = The Velocity of the steam flowing in the pipe, in feet per minute.

Steam Leads, or Branches

AN old rule for finding the area of a steam pipe supplying an engine, or pump, is as follows; To find the area of the steam pipe in square inches, multiply the area of the high pressure cylinder, in square inches, by the piston speed, in feet per minute, and divide the product by the steam velocity (in the pipe), in feet per minute.

This rule is based on the assumption that the cylinder is filled at each stroke of the piston.

In steam engine practice, however, the fact that the steam is, in most cases, taken from the pipe intermittently, due to the cutoff in the steam chest, should be taken into account.

This is not true, of course, in steam pump work where the steam is taken throughout the full stroke, or in steam turbine work, where the steam flow is practically uniform and constant.

TABLE II. ACTUAL INTERNAL AREAS OF STANDARD AND EXTRA HEAVY WROUGHT IRON AND STEEL PIPE

COL. 1	COL. 2	COL. 3
PIPE SIZE INCHES	A = AREA IN SQUARE INCHES	
	A STANDARD WT. PIPE	A EXTRA HEAVY PIPE
1	0.86	0.71
1 1/4	1.50	1.27
1 1/2	2.04	1.75
2	3.36	2.93
2 1/2	4.78	4.21
3	7.38	6.57
3 1/2	9.89	8.86
4	12.73	11.45
4 1/2	15.96	14.39
5	19.98	18.20
6	28.88	25.98
7	38.74	34.47
8	50.02	45.66
9	62.72	58.43
10	78.82	74.66
11	95.03	
12	113.09	108.43
OUTSIDE DIAM.		
14X3/8 THICK	137.89	
15X3/8 "	159.48	
16X3/8 "	182.65	
18X3/8 "	233.71	
20X3/8 "	291.04	

As an example showing the application of the above rule; assume a 500-hp. cross compound condensing engine having a 16-in. diameter high pressure cylinder, 48-in. stroke, and running at 80 r.p.m., the steam pressure is 170 lb. gage, saturated steam, and the engine consumes about 12 lb. of steam per horsepower per hour. The steam is cut off in the steam chest at ¼ stroke, assuming a trial velocity of 6000 ft. per minute, steam flow, we get

$$\text{area of steam pipe} = \frac{(16^2 \times 0.7854) \times (80 \times 2 \times {}^{48}/_{12})}{6000}$$

$$= \frac{201 \times 640}{6000} = 21.44 \text{ sq. in.}$$

—From Table II we find the nearest size pipe to be 5-in., having an external area of 19.98 sq. in.

If we take into account the fact that the steam flow is intermittent, due to the cutoff in the steam chest, we may compute the pipe size as follows: The steam consumption of the engine is, 500×12=6000 lb.

per hour, but as the steam is cut off at ¼ stroke, the steam is taken for each stroke, only during ¼ of the time required for the completion of the stroke, and the 6000 lb. of steam will flow through the pipe in ¼ of an hour, or 60÷4=15 min.

Therefore the equivalent weight of steam flowing through the pipe in one minute will be 6000÷15=400 lb. per minute=P.

From formula (1) we get;

$$A=\frac{144\times P\times S}{V} \quad (1)$$

and substituting 2.47 for S —(See Table I), 6000 for V, and 400 for P, we get;

$$A=\frac{144\times 400\times 2.47}{6000}=23.73 \text{ sq. in.}$$

From Table II, in column 2, we find our choice to lie between a 5-in. pipe having an internal area of 20 sq. in., and a 6-in. pipe, having an internal area of 29 sq. in. From Formula 2, we find the velocity in the 5-in. pipe to be;—

$$V=\frac{144\times P\times S}{A}=\frac{144\times 400\times 2.47}{20}=7114 \text{ ft. per min.}$$

and the velocity in the 6-in. pipe to be;

$$V=\frac{144\times 400\times 2.47}{29}=4906 \text{ ft. per minute.}$$

Where the steam pipes to engines connect to receiver type separators having a cubic capacity at least 3 times or more that of the high pressure cylinder, the steam connection from the separator to the engine may be made the full size as called for by the engine builder and the steam pipe supplying the separator may be made considerably smaller as the steam flow is more uniform when a separator is used.

In all cases, the separator should be placed as near the engine throttle as possible. The object of the receiver type separator is to provide a full supply of steam close to the engine throttle, from which the engine may draw its supply for any sudden increase in load, without causing an excessive drop in pressure at the engine throttle. The separator also provides a means of cushioning the steam near the engine throttle, thus preventing vibrations and hammering in the piping system, caused by the stopping and starting of the steam flow with every movement of the engine valve. With a large separator placed in the line close to the engine valve, the flow of steam from the boilers to the engine is more rapid and uniform as the steam expands, to a slight extent, in the separator every time the valve opens.

In the above example, if we assume a large receiver type separator to be placed near the engine, we could assume a steady rate of flow in the direction of the engine, but to be on the safe side, say we assume a uniform rate of flow in the engine supply pipe, for, say ¾ of the stroke. On this assumption the 6000 lb. of steam per hour, required by the engine, will flow through the supply pipe in ¾ of an hour, or 3×60÷4=45 min., and the equivalent weight of steam flowing per minute, will be; 6000÷45=133 lb. Substituting in formula 2, we get

$$A=\frac{144\times P\times S}{V}=\frac{144\times 133\times 2.47}{6000}=8 \text{ sq. in.}$$

From Table II we find our choice of a standard weight pipe to lie between a 3-in. and 3½-in. standard size. The area of the 3-in. pipe is 7.38 sq. in., and the area of the 3½-in. pipe is 9.89 sq. in. As 3½-in. pipe is an odd size, the 3-in. should be given the preference.

When the steam flow is constant, or approximately so, as is the case for steam turbines, pumps, etc., the equivalent weight of steam, to be substituted in formulas 1 and 2 is, of course, equal to the total weight of steam consumed, in pounds per minute.

As an example showing the application of formula 3, take the following:

How many pounds of saturated steam at 170 lb. gage pressure will flow through a 5-in. standard weight pipe in one minute, assuming the steam to be traveling at a uniform velocity of 6000 ft. per minute?

Answer; From formula 3 we have;

$$P=\frac{A\times V}{144\times S}=\frac{20\times 6000}{144\times 2.47}=337 \text{ lb. per minute or}$$

337×60=20,220 lb. per hour.

High Steam Velocities for Large Units

VELOCITIES as high as 20,000 ft. per minute may seem unreasonable to some readers, but when we stop to consider that steam turbines are now being built in units up to 30,000 kw. capacity, and that authorities prophesy a demand for single units almost twice this size in the near future, steam velocities as low as 6000 or even 8000 ft. per minute, which were considered extremely high a few years ago, would require extremely large and costly steam pipes, valves and fittings to convey the steam to such large units as are being manufactured to day.

Take for example a 30,000-kw. steam turbine operating on 15 lb. of steam per kilowatt per hour. The approximate total steam consumption per minute would be 30,000×15÷60=7500 lb. Assuming superheated steam at 200 lb. absolute or 185.3 lb. gage pressure, and 150 deg. superheat we find from the steam tables, a specific volume of 2.86 cu. ft. per pound of steam, at the given pressure and temperature. Substituting the above in formula 2 and assuming a velocity of 20,000 ft. per minute in the pipe we get;

$$A=\frac{144\times P\times S}{V}=\frac{144\times 7500\times 2.86}{20{,}000}=154.5$$

sq. in., as the required internal area of the steam pipe. The nearest size pipe is 15 in. O. D. Pipe.

If we fix the velocity limit at 8000 ft. per minute we would get;

$$A=\frac{144\times 7500\times 2.86}{8000}=386 \text{ sq. in., as}$$

the required area of the steam pipe supplying the unit. This would mean a pipe having an inside diameter of approximately 22 in. The above examples, rules and formula do not take into account friction and pressure drop, but simply show the method of arriving at pipe sizes for given conditions. When making calculations for pipe size it is advisable to check the sizes for friction and pressure drop, and if necessary change the sizes accordingly.

Long pipe lines, containing numerous elbows, valves, and fittings, which tend to restrict the flow, should always be figured for friction loss and pressure drop especially when high steam velocities are employed.

WORKING UP AN ENGINE TEST

The Convenience of Regular Forms for Making the Calculation and Recording the Steps and Final Results

IN making any computation it is desirable to have a regular form and method of doing work, first because such a form simplifies the process and makes sure that the work is done in the most expeditious way, second, because it leaves the data and computations in such a form that they can readily be referred to for verification and checking. Each engineer will probably have his own ideas as to just the form which this computation sheet should take, but 2 suggested forms, one for working out a test by the use of the slide rule, the other by using logarithms, are herewith shown. Of course, either form might be used where the computations are made by arithmetic, the first form being as well adapted to that as to the slide rule. The second form is made especially for convenience in logarithmic computation.

While there is not space here to go into the method of using a logarithmic table, we expect to take up that method of computation in later issues and would recommend that every engineer become familiar with it, as it is a great time saver although not as rapid as the slide rule, and is not difficult to understand and use.

For the first form the items are nearly self-explanatory down to the horsepower constant. The dimensions of the engine are, of course, obtained by careful measurement. The areas for head and crank end can be most easily obtained from the areas of circles given in the back data sheets of Practical Engineer, the area for the crank end being found by subtracting the area of the piston rod from that of the head end. The scale of the indicator spring must be obtained by calibration. While indicator springs are approximately correct, it will be found

Date of test MAY 29 Number of test 18
Diam of cylinder, inches 12 Area head end 113.1
" " piston rod " 1 7/8
Area of piston rod sq in 2.761 Area crank end 110.34
Length of stroke, inches 18 feet 1.5
Scale of indicator springs, head 59 Crank 59.3
Indicator cards number 1 to 24
Duration of test 2 hr.
Pressure at throttle 129 lb gage
Temperature in steam chest 354.5°F.
Quality of steam DRY + SATURATED
Back pressure, exhaust pipe 2 lb.
Horsepower constant, I.H.P. at 1 R.P.M. Head end 0.00514 Crank end 0.00502
Average speed R.P.M. 228
Planimeter reading of I.H.P. Head 30.3 Crank 38.2 (Base of 60 lb. spring)
Correction factor for indicator spring
Head 0.984 Crank 0.988
I.H.P. " 3495 " 4325
" total 78.2
Steam used total 3937 per hr. 1968.5
" per I.H.P. per hour 25.14

FIG. 1. COMPUTATION SHEET FOR ARITHMETIC OR SLIDE RULE WORKING

that in almost all instances there will be a slight variation, usually a pound or less, and in accurate work this needs to be taken account of in making computations.

Duration of the test is from the observations. The pressure at the throttle is the average of the pressure readings during the test, the temperature likewise the average; quality of steam is usually found by the use of the calorimeter; back pressure by a gage attached to the exhaust pipe near the engine, the readings being averaged for the test. The horsepower constant can be taken from the table of such constants given in the back data sheets of Practical Engineer, but it should be noted that in that table the constant is given as for both ends of a double-acting engine, and where the horsepower of the 2 ends is being computed separately, as in this case, the constant should be divided by 2. In the case of the present engine, 12 by 18 in., the constant is given as 0.01028, which divided by 2 gives 0.00514.

For the crank end the constant is found by use of the slide rule. Taking the head end constant, we divide by the area for the head end and multiply by the area for the crank end, that is set the runner to

Date of test 5-7-12 Number of test 20
Indicator cards number 1045 to 11:45
Duration of test 1 HOUR
Quality of steam DRY + SATURATED
Steam pressure at throttle by gage 148 LB.
Back pressure in exhaust pipe by mercury column 0 lbs. atmosphere
Indicated horse power 93
Steam consumption per I.H.P. per hour 24.7 LB.
Conditions

Diameter of cylinder = 16.046"
Diameter of piston rod = 2.855
Effective area of cylinder, head end = 202.22017 sq in
Area of piston rod 6.40181 " "
Effective area of cylinder crank end 195.81836 " "
Length of stroke 22" = 1.83333'
Scale of indicator springs, head end 78.96; crank end 78.62

	Head End		Crank End	
	Number	Logarithm	Number	Logarithm
Horsepower constant for I.H.P. and 1 R.P.M.	.01	2.34453	.01	2.00176
Average speed in R.P.M.	228.43	2.35866	228.43	2.35866
Planimeter readings (on 60 lb spring)	30.4	1.48287	38.4	1.58433
Factor of indicator springs	.9907	1.99631	.9932	1.99742
Indicated horse power	52.80	1.71900	40.90	1.61170
" " total	93.10	log 1.96889500		

	Number	Logarithm
Weight of steam used in 1 hour in lb.	2299.6	3.36153
Indicated horse power, total	93.10	1.96895
Weight of steam per I.H.P. per hour, in lb.	24.70	1.39258

FIG. 2. A COMPUTATION SHEET FOR LOGARITHMIC TABLE CALCULATIONS

514 on scale D, bring 1131 on scale C to the runner and carry the runner to 1103 and the value 502 (0.00502) will be found on scale D under the runner index mark. The average speed is found as the average of speed readings for the test.

The planimeter reading is found in the usual way with the planimeter set for 60 lb. scale, which is the nominal scale reading of the indicator spring. The correction factor for the indicator springs is found for the head end by dividing 59 by 60, for the crank end by dividing 59.3 by 60, giving the values as shown in the computation sheet. The indicated horsepower is then found by the regular rule, the only difference being that the mean effective pressure as shown by the planimeter must be multiplied by the correction factor.

Then for the head end, we have the mean effective pressure 30.3 multiplied by the correction factor, 0.984, by the horsepower constant for the head end, 0.00514, and by the number of revolutions, 228.

The horsepower constant includes the length of the stroke in feet times the area of the head end in square inches, divided by 33,000. The slide rule computation would be, place the runner at 303 on scale D. Bring 1 on scale C to the runner, letting the slide project to the left. Bring the runner to 984, bring 1 on scale C to the runner, slide still projecting to the left; carry the runner to 514 on C; bring 1 on scale C to the runner, letting the slide project to the right; carry the runner to 228 on C. This completes the computation and under the runner on scale D will be found 3495, which by either knowing about the horsepower that these conditions ought to produce, or by the approximate cancellation method we find to be 34.95 horsepower. A similar calculation for the horsepower at the crank end gives 43.2. The total is 78.2 hp.

Total steam used must be found either from weighing the condensed steam from the engine or if the boiler supplies only the engine under test the water fed to the boiler. Usually the water weights are taken every 5 min. The sum of these weights throughout the test gives the total weight used, the figure in this instance being 3937 total. As the test is 2 hours in length, the steam used per hour will be half this or 1968.5. To get the steam consumption per hour per indicated horsepower we divide this steam used per hour by the total horsepower, or on the slide rule we set the runner at 1968 on scale D, bring 782 on C to the runner and under 1 on C we find 2514 on scale D, which by inspection is easily seen to be 25.14 lb. as the steam used per hour per indicated horsepower.

The second sheet gives the consumptions for one of the tests on the Ide engine described in the June 1 issue, and the sheet is one devised and used by A. L. Ide & Sons, in their engine test work and is presented by the courtesy of that firm. It is recommended as a convenient form for the logarithmic method of computation.

Data above the heavy line are found from the measurements or averages from test readings. Areas of piston, etc., are computed as for the previous example and recorded as part of the sheet since these do not change for a given engine.

Horsepower is found by multiplying together the horsepower constant, the speed, the m. e. p. from planimeter reading and the correction factor for the indicator springs. This is accomplished by adding the logarithms of these quantities and this sum is the logarithm of their product. From the table of logarithms we then find the product itself, the horsepower for one end of the cylinder. Then add the power for the 2 ends and divide the total weight of steam used in 1 hour by the total horsepower. This is done by subtracting the logarithm of the divisor from that of the dividend, giving as a remainder the logarithm of the quotient. Then from the table of logarithms find the quotient, which is the steam used per hour per horsepower.

An English paper makes the statement that 40 firms are building turbines in England, 20 building marine turbines exclusively. Of the marine turbines built, all but 2 are of the reaction type; but of the land turbines 14 are impulse machines of various designs. At least 2 firms are specializing in small turbines. On the Continent there also appear to be 40 firms known to build turbines. About 8 are reaction turbines and the remainder impulse.

SHOWING UP THE CHIEF

By Thos. C. Robinson

In a plant where a young, wise engineer was at one time employed was a 20 by 48-in. Corliss engine which exhausted through a Berryman feed-water heater which was located about 80 ft. from the engine and the exhaust line having about 4 ft. drop toward the engine, consequently forming a huge pocket which retained all accumulated condensation caused by the engine standing all night with the bleeder open, besides being helped by several leaky tubes in the heater, and when the engine was started each morning there would be pounding about the base of the heater.

Our wise engineer had been on the job but 2 days when he went to the chief engineer and explained about the pounding of the heater's base, and the pocket in the exhaust line and the necessity of drainage. The chief said he would think it over sometime when he had nothing else to do, that the pounding wasn't anything new to him, as it had been that way for years.

Next, the oldest battery of boilers went back on the fireman. He "couldn't keep 'em hot," so he said; "wasn't enough draft." The chief ordered our friend to clean up the boilers good and to examine the baffle plates and see that the fire was cut up properly. This was done and in doing it our friend found that the brick walls of the setting were loose and full of great holes, which fact he reported to the chief. But the chief would not give our friend credit, but got a different grade of coal, cleaned out the base of the stack, overhauled the dampers, tested the feed water temperature, took cards from the engine and what not, but all without the desired result, then finally said said he had thought for 4 or 5 yr. that those walls were in bad shape.

Next, the engine bearings and crank end crosshead pins got hot. "Don't you know that that engine needs oil?" asked the chief. "She is getting it, chief," was our friend's cordial reply, "and besides I cleaned those bearings out good day before yesterday, too." At noon our friend examined the shaft for alinement and found the outboard bearing 5/16 in. too low. This was reported to the chief. The chief said: "I guess not. That bearing has been there 15 yr. Your level and things don't work right. You got some sand or grit of some kind in your oil; strain some of it real good and see if that doesn't help." The chief, after placing a vest pocket level on the shaft while the engine was running, pronounced the shaft level, but the next day had to shut down and raise the outboard bearing up to where it belonged, which required a week's time.

Next came an expert indicator man to find out how she was cutting off and strewing her steam around, and this same expert had taken a little too much intoxicant. But after taking several cards it was shown that the cutoff was much later on one end than on the other and the expert wanted to change the lap on the late cutoff and by adjusting the length of the steam rod from the wrist plate to the crab-claw. All the other events as shown by the cards were good, and our friend would not let the expert change the lap, but told him to adjust the relative lengths of the governor rods, and this the expert would not do, so the chief, not being present, was called and our friend was told where he belonged and that he must not meddle in things that he did not understand, and when our friend tried to explain he was sent to the office for his time.

VERTICAL CURTIS STEAM TURBINES

Practical Suggestions for Setting Up, Lining, and Balancing

STEAM TURBINES HAVE so rapidly invaded the domain of the reciprocating engine that every engineer should be conversant with their operation and maintenance. Successful operation of turbines depends to a considerable extent upon the engineer's understanding of their mechanism and proper handling.

Suggestions given in this series of articles are based upon the advice of the manufacturer, and the sectional illustrations with keys should enable the reader to fully comprehend the construction of all the parts.

Vertical Curtis Turbines

THIS set consists of a Curtis steam turbine with hydraulically-operated valves, direct connected to a generator of the alternating-current type. The general arrangement of the unit is shown in Fig. 1. The turbine is of the multiple stage type, each stage having 2 sets of revolving buckets and a single set of intermediates or stationary buckets.

Steam is admitted through a strainer to the combined emergency and throttle valve, thence to the steam chest whence it is admitted by the governing mechanism to the several first stage nozzles, passes through the first row of revolving buckets, through the intermediates and then through the second row of revolving buckets on the first stage wheel, and in the same manner through the nozzles and buckets of the succeeding stages and finally to the exhaust.

The diaphragms bear a heavy pressure from steam on their high pressure sides, and this pressure holds them in place and makes steam-tight joints; plugs which are let into the diaphragms and have a sliding fit in the recesses of the casing or intermediate holder are employed for centering.

Foundations

RIGIDITY in the foundation of the turbine is of the utmost importance, since any deflections or movements of base will affect the proper action of the step bearing. The floor of base casting, whether the base is built as a condenser or simply as an exhaust chamber, is not made sufficiently stiff to afford the degree of rigidity desirable for supporting the step bearing. It is therefore necessary to bond this floor solidly to a foundation of concrete or masonry.

This foundation can stand upon the ground or can be supported by steel work or other structure, but as a whole should be isolated from the foundation or walls of the building. It need not be unduly heavy if it provides the desired rigidity to prevent springing of the base; although, in general, the more massive the foundation, the less chance there is for vibration of the machine.

Bases of all Curtis turbines, whether built for condensers or not, have been provided with double bottoms having large openings presented to the foundation surface. It has been intended to provide holes in all cases by which grouting can be run into these openings. It is of utmost importance that all turbine bases be grouted to their foundations in a substantial manner so that the base and foundation will form one solid mass. If the grouting is of such a character that there is any looseness between the base and foundation, such looseness is almost sure to result in slight distortion and consequent bad action of step bearings.

When turbine bases are set, they should be supported on wedges which hold them at least ¾ in. clear of the foundation surface to which they are to be grouted. The level of the foundation around the outer edge should be so raised with a wall embankment that the liquid pressure will cause the space under the base to be filled. The space between foundation and base at the opening for the step bearing should be stopped up and calked with waste or other substance, in such a manner that the grout cannot escape at this point.

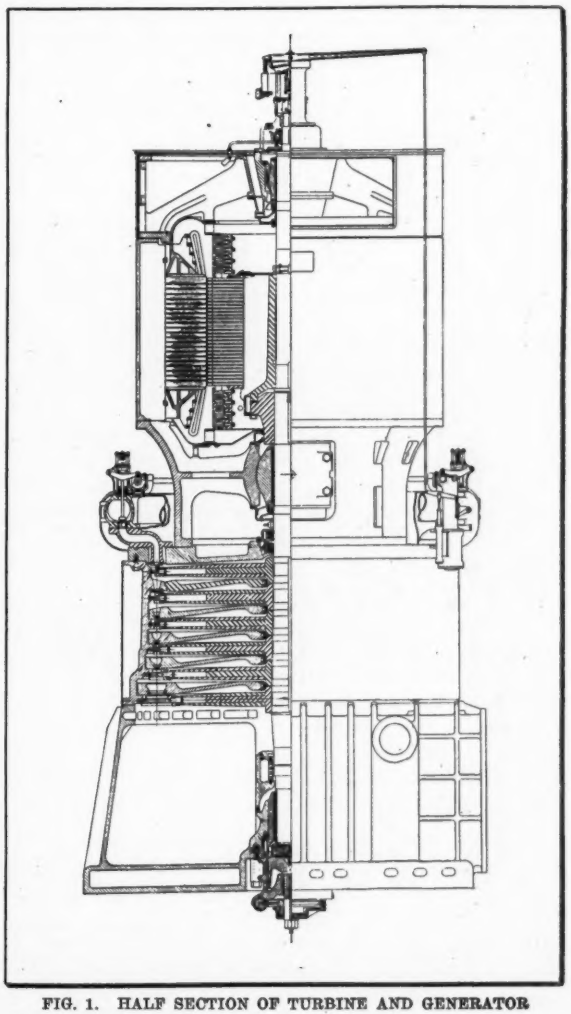

FIG. 1. HALF SECTION OF TURBINE AND GENERATOR

The grout should be thin and consist of cement and water; the upper surface of the foundation should be covered with pockets or grooves so that the grout will have a good bond.

In large base castings, holes are provided in side walls and through the floor of the base so that the grout may be properly distributed. All of the holes in the floor of base must be carefully plugged and made vacuum tight.

Grouting must be done before the shaft is put in and allowed to stand for several days before any weight is put upon the base. If the base casting is

distorted by weight before the grouting is set, or if the grout is crushed by weight before it has hardened, the purpose of this construction will be defeated.

Setting Up

FOR turbines supplied either with split exhaust or split condenser base, it is first necessary to get the halves properly assembled. It is advisable to use a thin, smooth mixture of red lead and linseed oil on the surface of the joint. As soon as lead is properly applied the body bound bolts should be inserted and drawn up in order to bring the halves into proper alinement. The remaining bolts can then be drawn up.

As soon as the base is properly assembled and grouted, and the step bearing is in place, the shaft should be stepped. In doing this care should be taken that as the shaft slips into position through the babbitted guide, the babbitt is not scraped and particles allowed to deposit between shaft and upper step block.

After the shaft is in position, the assembly of wheels and diaphragms will follow. In assembling diaphragms, care should be taken that diaphragm packings are in proper condition and have proper

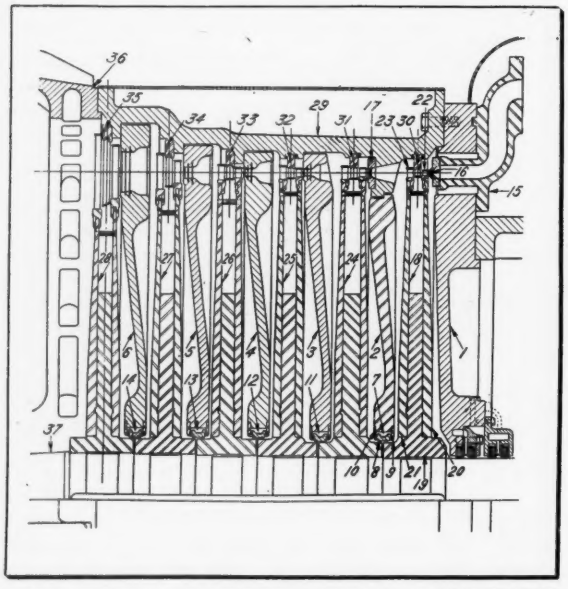

FIG. 2. SECTION OF TURBINE WHEELS AND DIAPHRAGMS

1, Turbine head with bolt; 2-6, diaphragms with centering pins; 7, first diaphragm packing; 8, sleeve for packing; 9, first retaining ring, and 10, second retaining ring, with rivets; 11-14, second to fifth diaphragm packings with same components; 15, valve casing; 16, first stage nozzle with bolts and locking device; 17, second stage nozzle with bolts and locking device; 18, first stage wheel; 19, bucket wheel spider; 20, first wheel disk, and 21, second wheel disk, with rivets and spacer; 22, first row bucket wheel segments with rivets; 23, second row bucket wheel segments with rivets; 19 to 23 constitute a complete wheel; 24-28, second to sixth stage wheels with same components; 29, intermediate holder section with bolts; 30-32, first to third stage intermediate segments complete with calking keys; 33-35, fourth to sixth stage intermediate segments complete with bolts and keepers; 36, base—exhaust or condenser; 37, turbine shaft.

clearances. Bucket clearances should be checked before the intermediate holder is closed up.

After wheels and diaphragms are placed, the wheel casing will follow. The surface of the joints in the wheel casing may be coated with oil, and then body bound bolts first placed in position.

As soon as the turbine proper is assembled, the armature stool, armature shield and valve casing will follow in due course. When the turbine and armature are fully assembled and step pressure is obtained, the shaft alinement should be checked as described under Shaft Alinement. After alinement has been obtained the carbon packings should be assembled. Care should be taken to see that rings fit the shaft properly and that springs have sufficient tension.

After the adjustments have been made, the machine should be run slowly and allowed to become thoroughly heated. At this stage all alinements should again be checked, then the turbine should be brought to speed before the field is placed in position in order to check the wheel balance. If this proves to be correct, the field should be placed in position and the unit brought to full speed and thoroughly heated with load. After this it may be necessary to alter weights in the field.

Shaft Alinement

ACCURATE alinement of shafts is essential to the smooth operation of turbines. In checking the shaft, first determine whether the shaft stands square with the base; this can be determined with sufficient accuracy by checking wheel clearances at 4 fixed points, openings in the casing being provided for this purpose. As soon as it is made sure that the shaft stands square, the shaft can be checked at the top either by means of an indicator, or by measuring to the shaft at 4 points, 90 deg. apart, from a fixed point on the frame. If the shaft is found to be out, in order to make an accurate check the shaft should be strapped over at the middle and bottom bearings, and then the above check repeated.

If the shaft shows a kink, the location of the kink should be determined. To do this it may be necessary to replace the top bearing and remove the middle bearing and indicate the shaft at several points between the top and bottom bearings. At times considerable information can be obtained by removing the top and middle bearings and allowing the shaft to revolve slowly. Two indicators should be used to take simultaneous readings at the top and middle. Under this last condition when the shaft is true it should revolve true within 0.005 in. total.

No shims should be used in assembling the coupling in order to aline 2-piece shafts. A loose ring is provided between the halves of the coupling which should be placed as marked. If satisfactory alinement is not given it should be obtained by shifting this ring or by removing and scraping it so as to throw the shaft in the required direction. It should be borne in mind that a small amount of metal removed from this ring will make a large variation in alinement.

Clearance

ALL turbine wheels are subjected to certain distortions through the effects of temperature variations. These distortions may cause one wheel to dish in one direction and another to dish in the opposite direction; consequently it is necessary to provide ample clearance so that the machine may be serviceable for all conditions. It is the intention to provide such large clearance that machines can be run under all conditions without adjustment of step bearing and without danger of injury to wheels. In setting up a machine care must be taken to obtain the full benefit of all clearance provided for by design.

If through inaccuracies or other causes clearance is impaired, the machine must be started with great care so that it will not be injured by rubbing. Where it is necessary to do so, clearance can be increased by turning off edges of wheels without taking the machine apart. If individual wheels are subject to unusual distortions which cause trouble in spite of such relief,

they should be replaced by other wheels. Increases of clearance within such limits as are practicable without cutting into buckets will not appreciably affect steam economy, and can be resorted to whenever necessary. All other adjustments should, however, be resorted to before the wheels are cut, and if clearance is increased, it should be only at the points where trouble occurs. With the types of wheels and the designs used in turbines of recent production, clearances as shipped are ample, if machines are properly assembled.

Locking Bolts and Nuts

EVERY precaution must be taken to prevent any parts of the revolving element from becoming loose; and it is equally important that no parts become detached and drop into the moving element of the turbine or generator.

Rivets should be used where practicable in such places; but if it is found necessary to use bolts and nuts, these should be locked so that it will be absolutely impossible for them to work out. Round head screws should not be used owing to the difficulty of positively locking them.

Steam Piping

STEAM piping should be as short and straight as possible, long bends being preferable to short ones. The strainer for the steam pipe which is always provided with the machine should be located close to the turbine and in a position convenient for the removal and thorough cleaning of the screen to avoid loss in initial steam pressure. The object of this strainer is to prevent foreign matter from entering the nozzles or passing into the buckets.

A drain pipe should be provided at the turbine, outside of the throttle valve, to carry off the condensed water from the steam pipe, and should be thoroughly blown out by steam to remove any dirt or scale before connections with the turbines are made.

In connecting steam piping care should be exercised to see that faces of flanges are parallel before bolting up and that all piping is properly supported in order to avoid undue strains upon the turbine.

Atmospheric exhaust connection should be made through an automatic relief valve so that in case of failure of the condensing apparataus the turbine will at once exhaust to the atmosphere and thus prevent an accumulation of pressure in the turbine and condenser.

Balancing

WHEN the unit is built, the wheels of the turbine and the rotor of the generator are given as good a balance as possible. This, however, may be slightly affected by shipping or reassembling, and the balance should be adjusted with great care when the machine is set up and before it is put into service.

The turbine part should at first be run with the rotor of the generator removed, and by successive trials should be brought to the best possible balance by attachment of weights to the upper and lower wheels, the lower wheel being accessible from the exhaust chamber, and the upper wheel being accessible through a hole in the top of casing provided for the insertion of balance weights. The weights should be screwed into threaded holes in the wheels and riveted over so that they cannot possibly work loose. In cases where no holes have been provided in wheels, or in top of machine for insertion of balance weights, these holes should be made before the machine is set up.

Good balance is highly important to the duration of bearings and the general reliability of machine. After the wheels have been balanced, the rotor of the generator should be assembled and should be balanced by running at all speeds, adding weights where necessary, at the points provided for the purpose. In balancing the machine by addition of weights, it is desirable to proceed systematically; first, to find the point where weight is required, and then to determine the exact amount of weight required. If this is not done, many unnecessary weights will often be used without properly accomplishing the desired results.

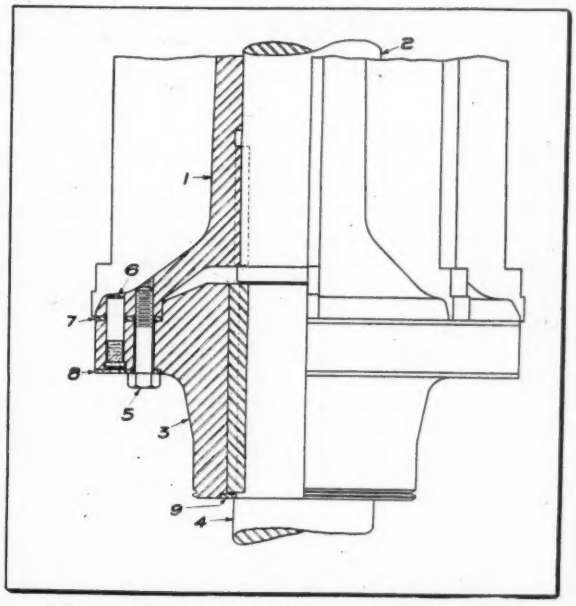

FIG. 3. SOLID COUPLING FOR VERTICAL TURBINE

1, generator field spider; 2, generator shaft; 3, turbine half coupling; 4, turbine shaft; 5, coupling bolts with lock washer; 6, dowel pin for coupling; 7, scraping plate for adjusting alinement; 8, retaining plate for dowels to be used in drawing same; 9, oil baffle plate.

In starting to balance it is advisable to make a chart in order to keep a record of the various trials. When it is found that balance cannot be corrected by weights some mechanical trouble must be located. It can always be definitely determined after a few trials whether weights will prove effective.

It is impossible to give definite rules for overcoming vibration. Each individual case must be carefully investigated and a remedy applied as such investigation suggests.

PREHEATING AIR for internal combustion engines was recently discussed in Le Genie Civil by A. Nougier. The author recommended passing the air over tubes in a preheater taking much the same form as a tubular boiler, the exhaust products from the engine cylinder passing in the reverse direction through the tubes. He claimed that it is possible to construct a heater capable of preheating the air to 175 deg. F., at no load without overheating the air at full load. Such a heater for a 200 hp. motor would be 23 in. in diameter and contain 100 tubes about 40 in. long.—Steam.

TOTAL SOOT DEPOSIT for a year in the city of London, Eng., has been measured and shows 650 tons per square mile, or a total of 76,050 tons. That at Surrey, on the outskirts was only 195 tons a square mile.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

PRACTICAL ELECTRICAL ENGINEERING

Single 2- and 3-Phase Generators; the Alternation, Cycle and Period; Leading and Lagging Currents, Power Factor

IN the Oct. 1 issue of Practical Engineer, Fig. 4 showed a loop of wire revolving in a magnetic field. Each end of this loop was connected to a separate collector ring and the rings were in turn connected to an external circuit. At each complete revolution of the loop we found that there was a complete reversal in the direction of the e.m.f., both in the revolving loop and in the external circuit, setting up what is called an alternating current.

In commercial a.c. generators there are, the same as in d.c. machines, a great many loops of wire; these are made up into numerous coils connected in series with the 2 free ends connected to the 2 collector rings.

To make the action of an alternator clearer refer

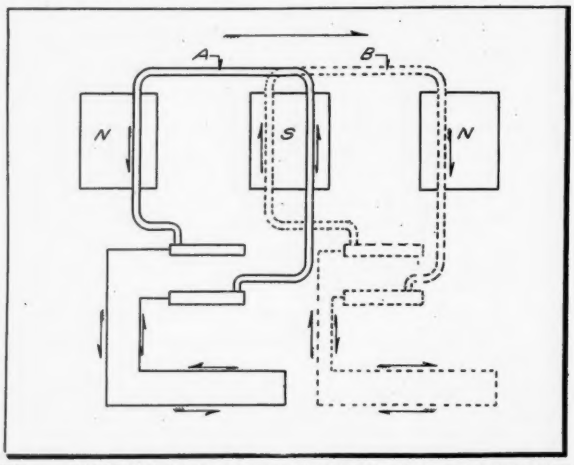

FIG. 1. DIAGRAMMATIC ILLUSTRATION OF AN A. C. GENERATOR

to Fig. 1. Let N, S, N represent pole faces of the field coils; when the coil A is in the position shown, and traveling in the direction indicated by the arrow, current will flow through the coil and external circuit in the direction of the small arrows. By applying Fleming's rule, explained in a previous article, this will at once be apparent.

When the coil is so placed that it occupies a position between adjacent poles, the e.m.f. becomes zero. As it moves further to the right in a position indicated by B, an e.m.f. is again set up in the coil, but in a direction opposite to that when the coil was in position A. This is obvious as the coil now occupies a position in which the lines of force thread through it in a direction opposite to that in its former position.

The variation of an alternating current as time elapses may always be shown by a series of wave-like curves as shown in Fig. 2. The circle at the lefthand side is divided into 36 parts, each representing 10 deg. Assume that the arrow pointing to zero indicates the position of a coil where the e.m.f. is zero. As the arrow moves successively to 10, 20, 30 deg., etc., up to 90 deg. the e.m.f. is constantly rising until the maximum is reached at the latter point. As the arrow continues its movement to 180 deg. the e.m.f. drops to zero and one alternation has been completed, that is, the e.m.f. has risen from zero to full position, and returned to zero.

Let the arrow move from 180 to 270 deg. when the e.m.f. has again reached maximum, but it is in a direction opposite to that when the arrow was at 90 deg. As the arrow moves from 270 to 360 deg. the e.m.f. again falls to zero and one cycle has been passed through; one cycle is 2 alternations and is illustrated by the curve from 0 to 360 deg. on the horizontal line OA.

The horizontal line is divided into a number of equal divisions represented by increments of time. The distance from T to T′ is called a period and represents the time of one complete cycle.

To describe the curves, horizontal lines were drawn from the intersection of each arrow position with the circumference of the circle and starting with the first time division to the right of zero, a point was marked on each succeeding horizontal line above each time division until the top line at 90 deg. was reached. The points were then marked in a downward direction on the horizontal lines until 270 deg. was reached, then upward again and so on until the completion of the diagram.

The number of cycles a second is termed frequency; the frequency of any a.c. generator being equal to the revolutions divided by the number of pairs of poles. Standard commercial frequencies at the present time are 60 and 25 cycles a second, the latter being used mostly for power and railway service and the former for lighting purposes. For single-phase railway work frequencies as low as 15 cycles have been used.

Leading and Lagging Current

UNDER many conditions of operation the current delivered by an alternating-current generator lags behind the e.m.f. or leads it; a leading current is shown by the dotted curves ahead of the e.m.f. curves and a logging current by the dot and dash curves behind the e.m.f. curves. Leading or lagging current gives rise to a condition where the apparent power delivered by the generator is not the actual power. The ratio between the apparent power in the circuit, volts multiplied by amperes, and the real power, is known as the power factor, and is always unity or a fraction thereof. When an alternating current circuit contains self-in-

duction, the current lags behind the e.m.f. and when the circuit contains capacity it rises ahead of the e.m.f., in each case the current and e.m.f. reach their maximum values at different instants and the product of the e.m.f. and current at any instant is less than it would be if the 2 were in phase with each other.

If the e.m.f. and current be measured separately, the voltmeter and ammeter will give individual mean effective values. If they are measured by a wattmeter, the instrument indicates their combined power effect, not the product of their effective values, which occur at different instants, consequently the wattmeter readings will be less than the product of the voltmeter and ammeter readings.

The relation of the actual power to this product of separate readings is the power factor of the circuit. It may be expressed in a formula in the following manner:

Power factor = Watts ÷ Volts × Amperes.

This has given rise to 2 methods of rating electrical apparatus, one on the basis of watts and kilowatts and the other on the basis of volt-amperes or kilovolt-amperes (kv.a.). The former represents the actual power, usually in kilowatts, and the latter the apparent power, usually in kv.a. generated, transmitted or used by the apparatus.

Alternating-current switchboards are equipped with an instrument called a power factor meter which indicates at all times the value of that quantity.

If the exact phase relation in degrees were known it would be possible to figure the power factor mathematically, but this is seldom done except for theoretical discussions.

When the current leads or lags 90 deg. from the e.m.f. it is said to be wattless and the power factor is zero. In practical work, wattless current does not enter the problems, but in the design of certain types of alternating-current apparatus the current is resolved into 2 components, the wattless or magnetizing component and the power component; but as these conditions enter into only the design of apparatus, they need no further comment here.

Self Induction and Capacity

SELF induction is present in many classes of alternating-current apparatus where there is a combination of windings and iron or steel. In a previous article we learned that wherever an e.m.f. rises or falls in a coil of wire with an iron core there is a shifting of the lines of force and an e.m.f. is induced into the windings in a direction opposite to that of the applied e.m.f. which retards the current to a greater or less degree; this is self induction. It is also present in long transmission lines as the lines of force about a conductor have the same tendency to set up an opposing e.m.f.

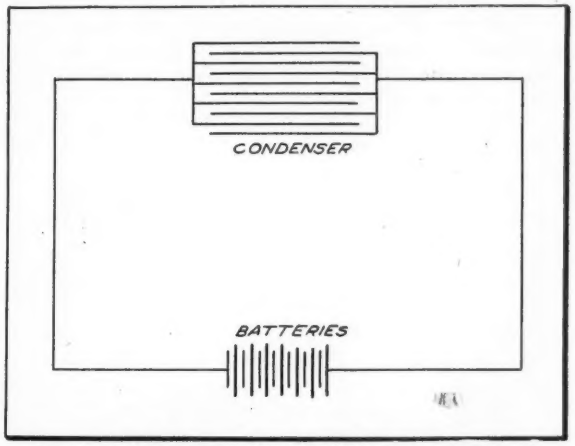

FIG. 3. CONNECTIONS AND DETAILS OF A CONDENSER

Capacity is present in lead covered cables or may be produced artificially by means of a condenser. Fig. 3 is a diagrammatic view of a condenser which consists of many sheets of tinfoil insulated from one another by suitable material, generally mica. Alternate strips are connected together and the opposite ends connected to the line as shown in Fig. 3; there is no electrical connection between the 2 sets of poles.

If a battery be connected to the terminals, a current will flow into the condenser and the plates will become charged. The flow of current will be maximum the instant the e.m.f. is applied, but will rapidly fall off and in a fraction of a second will cease, when the condenser is said to be charged. It will remain so until the terminals of the condenser are connected together, when it will discharge and a current of short duration will flow through the conductor.

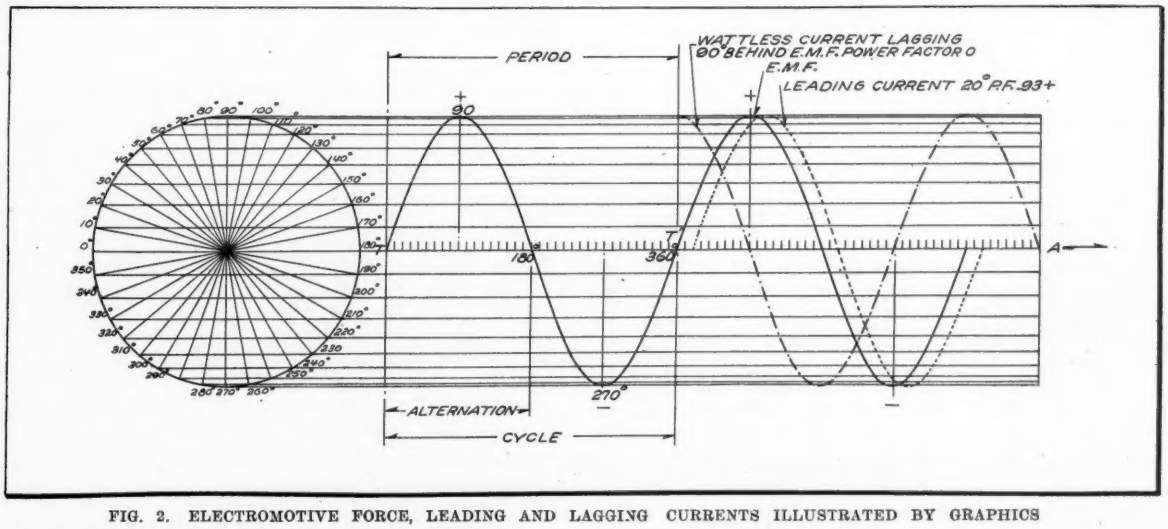

FIG. 2. ELECTROMOTIVE FORCE, LEADING AND LAGGING CURRENTS ILLUSTRATED BY GRAPHICS

This action can best be illustrated by the action of a compression spring, forcing the convolutions together, being analogous to charging, and suddenly releasing the spring and letting it assume its original form can be compared to the discharge of the condenser.

If instead of a battery an alternator is connected to a condenser with an ammeter in circuit, the ammeter will register continuously the same as when connected in a metallic circuit.

Where there are many induction motors on a circuit there is invariably a lagging current which is greatly retarded if they are underloaded. Some manufacturers of induction motors employ a condenser to compensate for the lag by virtue of the condenser's tending to cause the motor to draw a leading current from the line.

LARGEST DIRECT CURRENT GENERATOR

Description of the Proposed Plant of the Southern Aluminum Co. at Whitney, N. C.

SEVEN vertical waterwheel type electric generators, which represent units of the largest capacity ever built for generating direct current, will be installed in the new plant of the Southern Aluminum Company at Whitney, N. C. Each machine will have a rating of 5000 kw., delivering 20,000 amperes at 250 volts and operating at a speed if 170 r. p. m.

Two smaller d. c. generators of the same type, rated 2500 kw. at 500 r.p.m.; 2 1250 kv.a. alternators, having a speed of 514 r.p.m., with 2 16-kw. exciters, and all necessary switchboards and controlling devices are also included in the installation.

The contract for all the electrical apparatus has been placed with the General Electric Company, and the installation will be one of the largest and most modern of its kind in the world. It is the intention of the Southern Aluminum Company to push to completion the project now under way and to have in operation in the course of the next 8 months a manufacturing plant that will turn out some 25,000 tons of aluminum annually.

The company was recently incorporated under the laws of the State of New York, with a capitalization of $8,000,000 and was organized by some of the largest aluminum manufacturing companies of Europe. The enterprise has been financed in France and is closely associated with L'Aluminium Francais of Paris. The work at Whitney is in charge of Dr. Paul Heroult, an eminent French engineer, who is recognized as one of the most expert authorities in the world on the manufacture of aluminum. Although Dr. Paul Heroult has been directing constructive operations there but a few weeks, remarkable progress has been made, and it is confidently expected that the entire plant will be in readiness for turning out the product of the company by the middle of 1914.

The plant throughout will rank among the greatest and most perfectly equipped for the manufacture of aluminum in the United States. Only one other in the country, at Niagara Falls, can compare with it. In the complement of building are 9 furnace rooms, wherein the alumina will undergo the various processes incidental to conversion into aluminum. Each of these structures measures 60 by 500 ft. and one electrode factory of similar dimensions is also included in the group.

Aluminum, because of its lightness and toughness, finds an almost universal application nowadays. Wire and cable made of this product are rapidly coming into extensive use for the transmission of high-tension electric power. A certain type of clay termed bauxite, which is found in Georgia and the middle West, enters into the manufacture of the commodity. From bauxite alumina is made, and through delicate and intricate electrolytic methods this is then transformed into aluminum.

Immense machines, which will supply electric current for the several operations of this vast industry, will be installed immediately over wheel pits and direct connected to vertical shafts of S. Morgan Smith turbines by forged steel flanged couplings. Each 5000 kw. generator will weigh in the neighborhood of 150 tons, measure 22 ft. in diameter and extend 13 ft. above the floor level. The entire rotating element of the generators will be supported from an overhead thrust bearing. While the normal speed will be 170 r. p. m., they will be designed with provision for a safety runaway speed of 75 per cent above normal. Simplicity will characterize the switchboards and controlling devices, and they will consist of types entailing an effective minimum number of parts. The wheel governors will be provided with remote electric control for both hand and automatic operation.

The establishment of the Southern Aluminum Company's plant at Whitney is transforming the site into a bustling city. While the construction of the plant is under way, it is anticipated that 2000 people will reside there, and 500 new concrete houses are being erected to accommodate the influx of population. Experienced chemists, electrical and hydraulic engineers and experts in every branch of the business will constitute the corps of Dr. Heroult, under whose able direction this comprehensive and important development will be consummated and also operated after successful completion.

CONCRETE FOR FOUNDATIONS

WE recently learned of a large engine of several hundred horsepower that is being installed on a concrete foundation, where too much earth was used in mixing. The result was that the engine would have torn the foundation to pieces in a very short time. In fact, it would have been impossible to install the engine, as the foundation did not dry out, and the engine erectors refused to try it. As a result the 6 weeks' old concrete is being shoveled out, which shows how soft it was. Concrete makes a good foundation, but to be so used it must be properly made. The Mason Builder gives the following advice about concrete:

Don't allow cement to freeze before it is thoroughly hardened.

Don't re-temper and use concrete which has become set on the mixing board.

Don't use a dirty or loamy sand.

Don't use soft stone or broken brick in concrete where great strength is required.

Don't expose freshly made concrete to the hot sun.

Don't allow concrete to dry out too rapidly.

Don't apply fresh concrete or cement mortar to an old or hardened surface without first thoroughly soaking with water, and hacking a rough surface on the old material. Clean thoroughly and apply a very thin cement wash.

Don't use a dirty or impure water in mixing concrete. —The Gas Engine.

ELECTRICAL DEVELOPMENT OF THE PANAMA CANAL

General Details of Gatun Hydroelectric Station

By A. P. Connor

OWING to the extensiveness of the operations involved in the construction of the Panama Canal, many important features, engineering and otherwise, which would have received more general attention, have been almost overlooked by those who have conveyed the general information concerning the canal to the public.

One of these subjects which is of an especially important nature is that which refers to the development of the energy to operate and light the canal. This energy will of course be electrical, and will be developed at a very low cost, by means of a hydroelectric power station installed at the celebrated Gatun Dam. The power will be obtained by using some of the excess water from the canal under the head or height which will be given by the water retained by the locks in the central or main part of the canal, that is, between the Gatun locks and the Pedro Miguel locks.

From this storage basin about 6000 kw. will be developed in the hydroelectric station, which may be increased if the conditions warrant it. The average height or head available throughout the year will be about 75 ft., the elevation of the tail race being 8 ft. above sea-level.

During the wet and rainy season on the Canal Zone, water will be plentiful and will be wasted over the Gatun spillway, but during the dry season, which is from December to May, it will be necessary to use the water stored behind the dam. It is of course understood that an enormous quantity of water will be required to supply the locks, as the ships pass through them, but even when this is subtracted from the minimum supply of water available, and also after allowing for leakage and evaporation, there will be water enough to keep the hydroelectric power fully supplied with water.

For several years to come there will be an abundant supply of water, and when the canal will have its full capacity of traffic, there will be enough water to keep the station going sufficiently to care for the demands required of it. In addition there will be a steam plant for developing electrical energy installed at Miraflores, so that the load can be properly taken care of under the severest conditions.

The electrical load on the Zone will not only consist of the many motors and other devices to operate the working parts of the Canal, but also that necessary to operate the machinery of the permanent machine shops, the drydock, the lighting of the canal proper and the lighting of the towns on the Zone.

It is expected to do away with the necessity of using coal for domestic purposes in the houses of the residents

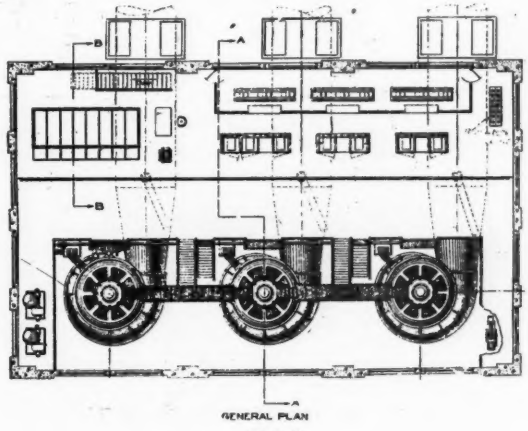

FIG. 2

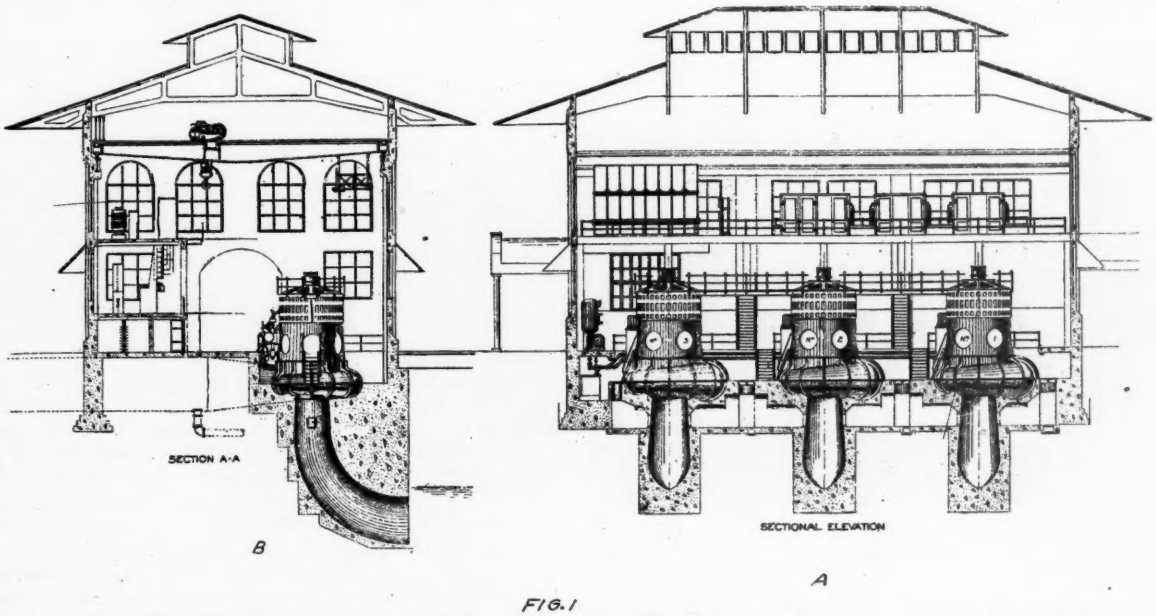

FIG. 1

FIG. 1. (A) LONGITUDINAL SECTIONAL ELEVATION OF GATUN HYDRO-ELECTRIC STATION. (B) CROSS-SECTIONAL VIEW
FIG. 2. GENERAL PLAN OF STATION

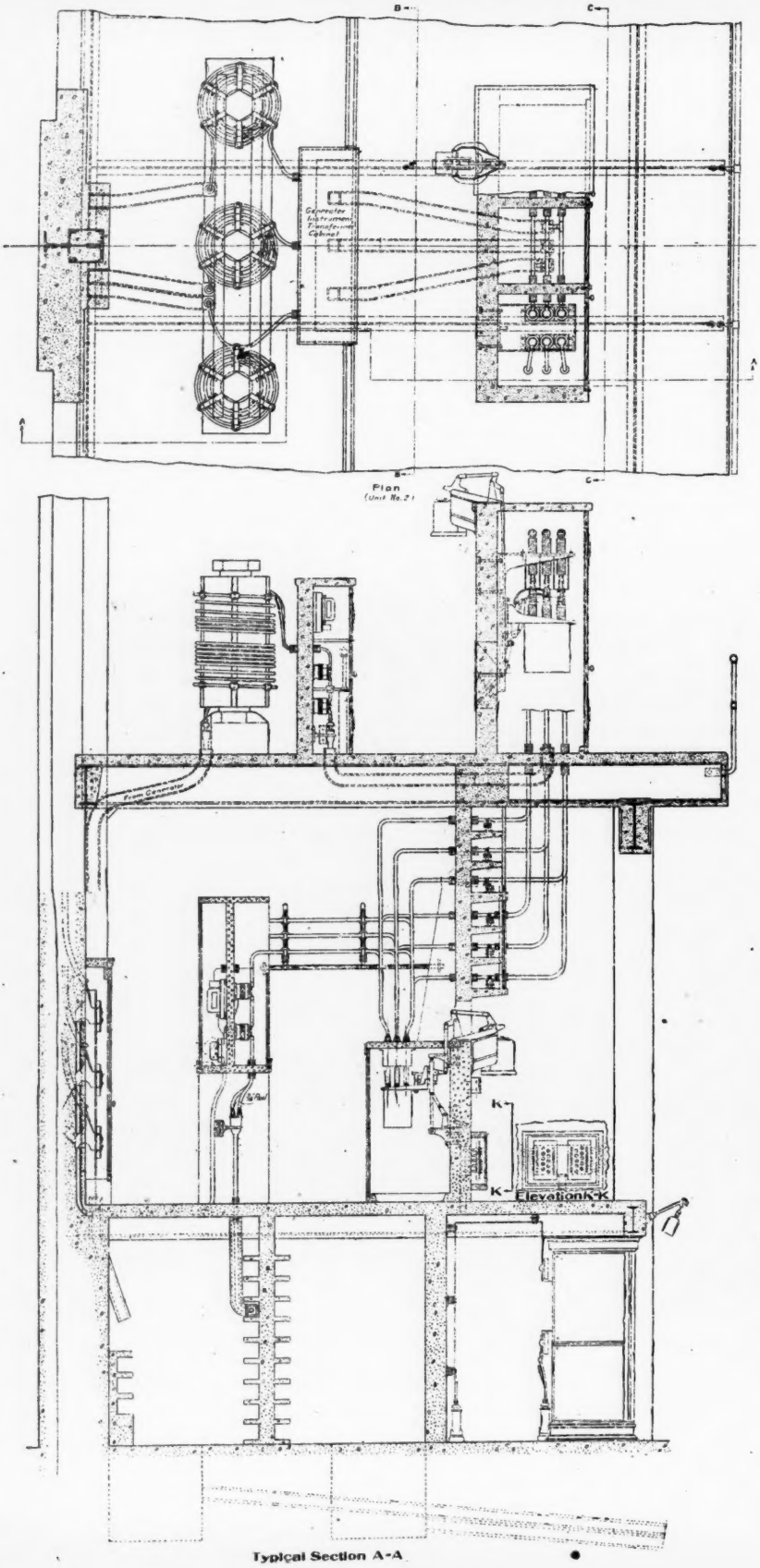

FIG. 3. GENERATOR OIL SWITCH GROUP

on the canal, which will mean a considerable saving to the government, as coal is very expensive on the zone. In all probability electrical cooking utensils will replace the stove and other heating devices now used on the Isthmus.

The Panama Railroad which is owned and controlled by the U. S. Government may also be eventually electrified and it seems safe to anticipate that it will, particularly if the traffic conditions on the railroad become severe. In order to insure an almost absolutely continuous service possible, a duplicate system of feeders will be provided wherever advantageous. The hydroelectric station will be connected by means of high voltage transmission line with the station at Miraflores which will serve to act in conjunction with it, particularly when the water is low, or the former station is shut down.

The hydroelectric station will be situated adjacent to the north wall of Gatun spillway and the building will be constructed of concrete and steel and of a design suitable for the conditions for which it is intended.

The building will be large enough to permit the installation of 3 2000-kw. units and for 3 additional units when the demand for them makes them necessary. A 30-ton crane is to be provided in the station for erecting and repairing the apparatus to be installed. Each unit consists of an individual headgate penstock, governor, generator, exciter and control devices.

The head of the water used will vary with the season about 8 ft. and the forebay for the water is constructed as an integral part of the curved portion of the spillway wall. This wall contains 5 large apertures in the forebay arranged to prevent floating debris from accumulating at the headgates.

From the forebay the water will be delivered to the turbines through 3 steel plate penstocks, each having an average length of 350 ft. These penstocks will be constructed of ⅜-in. plates riveted together and making a pipe 10 ft. 6 in. in inside diameter. The exterior of the penstocks will be covered by a substantial coating of concrete to serve both

as a protection against corrosion and as a means of strengthening the penstocks against superimposed earth pressures which will be piled upon them eventually as the Gatun Dam is finished.

Turbo-generator units are to be of the vertical type, the entire weight of the rotating element being suspended from an overhung thrust bearing which is supported from the top shield of the generator. The turbines are rated at 2250 kw., at a speed of 250 r.p.m., and will require about 5000 second-ft. of water at full load. The generators will be 3-phase, 25 cycle at 2200 volts potential.

Many special features exist in the proposed plant, such as remote control switches, storage batteries, and exciters mounted on the same shafts as the generators.

No noticeable attempt has been made by the Isthmian Commission to vary from standard practice in the designing of the machinery and apparatus to be used in the power plant at Gatun. In fact the size of the units to be used are comparatively small for up-to-date practice which however will give more flexibility to the system and serve the conditions much better than larger ones would.

Some of the exciters are to be mounted on the shafts of the turbo-generators and other exciters will be operated by induction motors situated on the main floor and arranged to feed into a storage battery set. This storage battery will serve to meet the needs of the station when the turbo-generators are shut down.

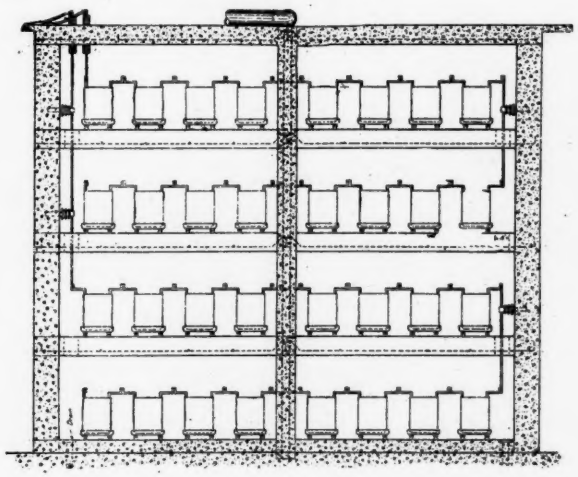

FIG. 4. STORAGE BATTERY CABINET

To give an idea of the amount of water there will be to draw from, it is calculated that when the Gatun Lake is at its maximum level, plus 87, the quantity of water in the lake will be about 192 billion cubic feet. At present the level of the lake is about plus 45, and the amount of water about 55 billion cubic feet. If one of the chambers in any of the canal locks was filled with water to the depth of 50 ft., it would contain approximately 5,500,000, cu. ft. which is about one-one hundred and fiftieth of the average daily increase in the amount of water in the lake during the rainy season.

While there are many features of interest in the construction of Panama Canal, it is especially satisfactory from an engineering point of view to know that it can be independent of coal for its fuel, and that itself, is capable of supplying electrical power for all of its direct and indirect requirements.

ELECTRICALLY OPERATED DRILLS

Drilling 1 1-16-in. Holes in 1-in. Plate in 4 Seconds at the Panama Canal

FOR the final riveting of the enormous lock gates at the Panama Canal the McClintic-Marshall Construction Company of Pittsburgh, has installed 16 special electrically operated machines for drilling and reaming rivet holes. Each of these machines weighs about 6 tons and is capable of doing the work of 5 ordinary type reamers.

The machines are designed to run on a standard gage track and are mounted on broad adjustable scaffolds which are suspended from brackets by chains from the top of the gate, as shown in Fig. 1.

The inclined hand wheel shown in Fig. 3 operates through a train of gears and moves the machine along the track. The tool can readily be moved as roller bearings are used.

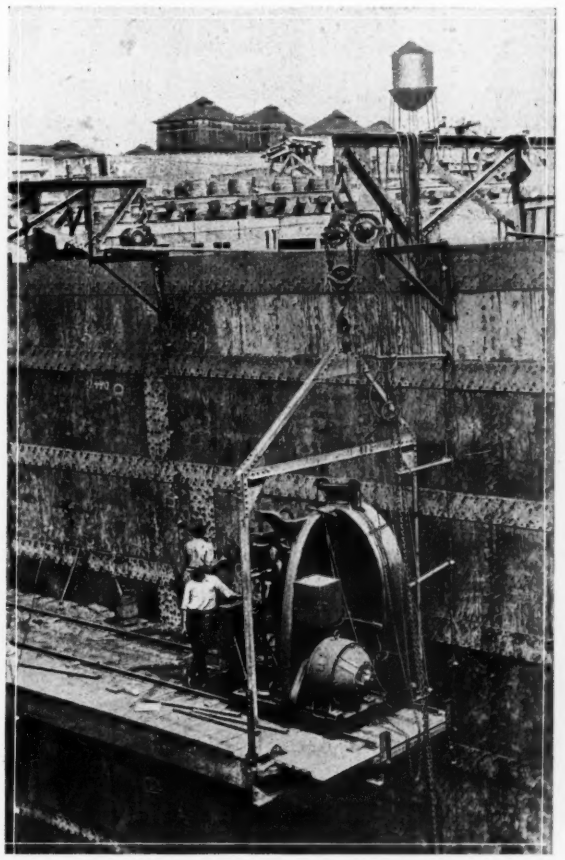

FIG. 1. DRILL ON SCAFFOLD SUSPENDED FROM BRACKETS ON TOP OF GATE

It will be noticed from Fig. 2 that the entire controlling mechanism is placed within easy reach of the operator. The horizontal hand wheel shown in Fig. 3, actuates suitable reduction gearing and a screw which raises or lowers the spindles, while the quick return motion through the spindles is actuated by means of the spider wheel, or by any of the 4 levers shown in Fig. 3. These levers automatically engage the quick return mechanism and enable the spindles to be run in and out.

Each machine is provided with 4 changes of power feed which are instantly available through the quick change gear mechanism. The length of the power feed is 16 in.

The clutch lever for placing either spindle in operation can be seen in Fig. 3 immediately above the number 15 on the head of the machine, while the feed changing lever is seen just above the clutch lever through the hand wheel. This hand wheel is used for raising and lowering the head, which in turn is accurately counterbalanced so that this raising and lowering is done with the least possible effort.

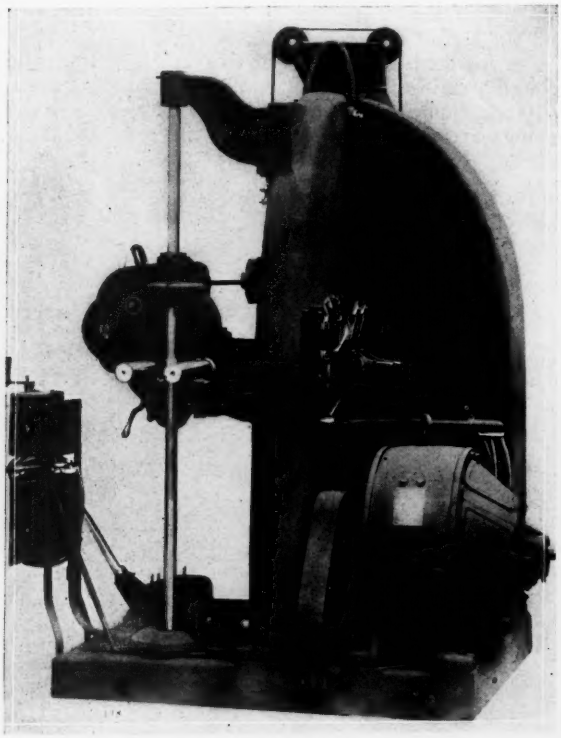

FIG. 2. SHOWING MOTOR AND CONTROLLER

Westinghouse direct current adjustable speed, shunt wound motors rated at 10 hp., 220 v. are used and the method of the driving is shown in Fig. 2.

These machines were placed in operation in February 1912 on the main gates of the upper lock at Gatun and it is intended to use them on all of the gates in the 3 sets of locks. They were designed and built by the Foote-Burt Company of Cleveland, Ohio, especially for use on the Canal. The distinguishing features are their great capacity, a total of 9 speeds, varying from very slow for heavy drilling, to very high for lighter reaming; and fixed spindles arranged to suit the uniform spacing of rivet holes in the lock gates. On tests made at Gatun, one of the machines drilled 1 1-16-in. holes through 1-in. plates in 4 seconds, or at a rate of 15 in. per minute.

CORRECTION

IN the article entitled "Practical Mathematics" in the Oct. 15 issue of Practical Engineer, page 1040, the sentence reading, "Then by the hp. rule, Percentage = Base × Rate, we have Developed hp. = 300 × 0.75 = 250"; the answer should have read 225.

FIFTY KILOWATTS OF WATER POWER

By Warren H. Miller

FIFTY additional horsepower were needed in a power house. Every boiler of the plant was being pushed to the utmost and it being necessary to add the badly needed increase of 50-horse, it was a problem for the writer to solve.

It happened that the company owned an old mill, down along the river and about ¼ mile in a direct line from the power house, and, as a last forlorn hope, the writer was sent as a scout to report on what the possibilities were of using any part of its water-power equipment to help out.

When I penetrated through the briers and weeds of its abandoned penstock the old place was utterly given over to Nature. Some former extra-high spring freshet of the river had swept away the dam, every vestige of the old overshot waterwheel and all the big timbers and underpinning of the mill. About all there was left to report on was 9 ft. of available head and a volume of about 6000 cu. ft. per

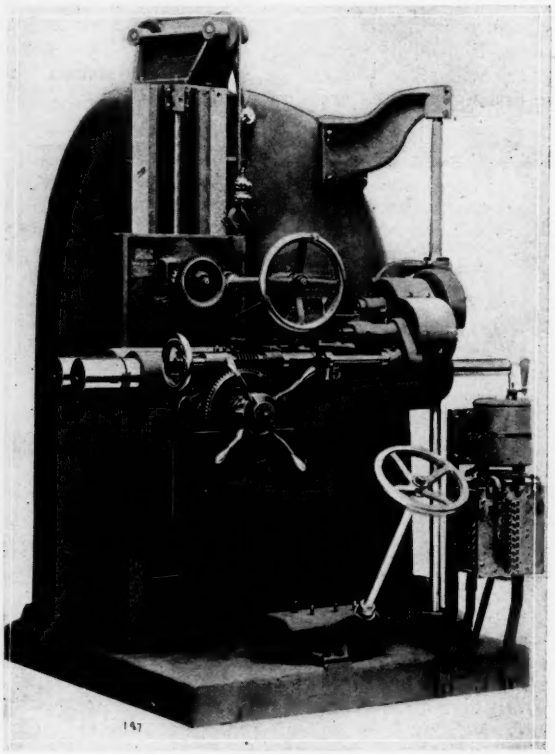

FIG. 3. FRONT OF DRILL

minute pouring through the ruins of the dam. The penstock was also in pretty fair shape, as it had simply acted as an immense trough during the flood.

Now 6000 cu. ft. a minute is roughly 100 hp., falling through 9 ft., a figure not to be sneezed at. Any good turbine will realize some 85 per cent of this theoretical horsepower, and we had in our power stock an extra 40-in. wheel, which would deliver 78.8 hp. on a 9-ft. head.

Making Estimates

TO repair the dam meant simply closing the upper race gate, putting some new planking in the breach and teaming in gravel enough to bring the earth fill

back to equal the original section of the rest of the dam. From the electrical department of the works could be had a 50-kw., 500-volt direct-current dynamo at cost price, transferred on the company's books, so the real expense of getting the power question solved would not run into any great figure.

The writer was ordered to get out an estimate and figure up a little transmission line to deliver 50 kw. at the main switchboard at 500 volts.

It should be explained right here that such current could not be put in on the main busbars of the power house dynamos, for these were all compound-wound machines, with the series coils of the fields connected by equalizers. As the equalizer must at times carry the full output in amperes of the machine, this would mean, not 2 wires, but 3 of full size on the transmission. So a separate lead always had to be found for the new dynamo, which was easily done, one double-throw switch giving us the choice of 2 shops.

Repairs and Additions

THE first care was the repair of the dam and the building of a turbine-well below the old penstock. The well was simply a large wooden box with the turbine at the bottom of it, sheathing of 4 by 12-in. yellow pine, and timbers figured to stand the static pressure of 9 ft. of water.

The turbine was of the inward-flow type, with a vertical shaft turning at 91 r.p.m. It discharged out of the bottom of the box directly into the tail-race, and the admission was controlled by a sliding gate-ring that simultaneously closed all the inlet ports to the turbine vanes, shutting them all off in about 3 in. of travel. This gate was manipulated by a rack-and-pinion with vertical valve rod on one side of the turbine, and a turbine governor.

With the turbine were 2 main bevel gear-wheels of cast iron with hard maple teeth, the one on the vertical turbine shaft having 54 teeth and the other having 40. This would make the revolutions of the main jack-shaft 120 r.p.m.

Driving the Dynamo

NOW, as the speed of the dynamo was 625 r.p.m., a pretty slow speed for that size machine, but the slowest obtainable in stock sizes, the problem would be how best to get from the 110 revolutions of the jack-shaft to the 625 of the dynamo.

Naturally the best way would be to belt direct to the dynamo, because the belt in any event would have to be not much less than 14 in. wide, and a counter-shaft rig with such large belts would hardly be located anywhere on the mill timbers without building a special trestle for it. The main jack-shaft would also have to go on the strong 16-in. timbers which formed the heavy foundation work of both mill and penstock, and these with rigid pillow-blocks would bring the main shaft about 37 in. above the surface of the water in the turbine well. This would permit a 72-in. wheel on the jack-shaft and would therefore call for a 14-in. pulley on the dynamo. Such a pulley, going at 625 r.p.m., or 35 ft. a second, would have to be 15 in. wide, since a double leather belt at that speed will transmit approximately 7 hp. per inch of width; and therefore a 14-in. belt would give 98 hp. This would develop the full strengh of the wheel and allow something for overloading the dynamo, say 25 per cent.

Following this line in preference to any counter-shaft alternative, the dynamo was located, as shown, on the main floor of the old mill, the belt passing through the floor to the 72-in. pulley below, the distance between centers being 15 ft.

Governoring

IT is essential to keep the speed of the dynamo constant, because the steadiness of the voltage depends in a great measure on the speed, and it must remain the same whether the load is light or heavy. Now the waterwheel tends to race on light loads and slow down to its normal on heavy ones, so it must have a governor to close its gates as the load gets less, and thus hold the speed steady. The one shown in the accompanying illustration is what is known as a compensating governor.

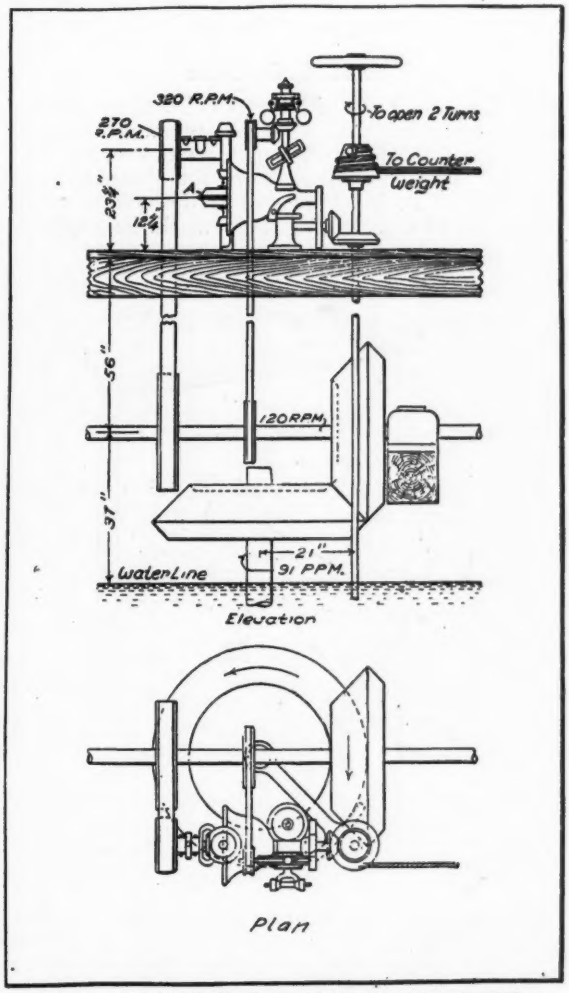

FIG 1. ARRANGEMENT OF GEARS AND GENERATOR

In order to make it delicate enough, the valve-turning machanism must be governed by the small balls which change their position due to variations of the speed. It will not do to have the centrifugal ball mechanism act directly on the valve rod, as it has but a small travel for the minute change in load. Therefore, the governor balls simply alter the vertical position of the 2 cup-shaped friction disks A. Inside of them rotates a solid disk driven by the large 12-in. pulley, and there is a scant 32-in. clearance between the faces of this disk and the cups which enclose it.

The governor ball mechanism raises the lower cup ever so little, it at once comes in contact with the interior disk, which is always spinning around, and so it goes around with it and thus turns the gate-valve rod by the gears shown on the rod. If, on the other hand, the governor ball mechanism lowers the upper cup a little, it comes in contact with the interior disk and thus actuates the valve rod in the opposite direction.

So, therefore, there is only one position in which the valve rod is left alone, and this is at the normal-voltage speed of the dynamo. The least variation from this speed calls the disks into play and the gates are opened or closed a trifle. With steady loads there is little for the governor to do, but with constant variations, such as with certain shop loads, the governor is incessantly making slight changes in the position of the gates.

Transmission Line

WITH a steady run of 5 teams building up the dam, and all orders placed for governors, dynamo, pulleys and belts, the next thing to go at was the transmission. Actual measurement of the distance showed it to be 1400 ft. from the mill to the central powerhouse. At 50 kw. the amperage would be 90 for 550 volts.

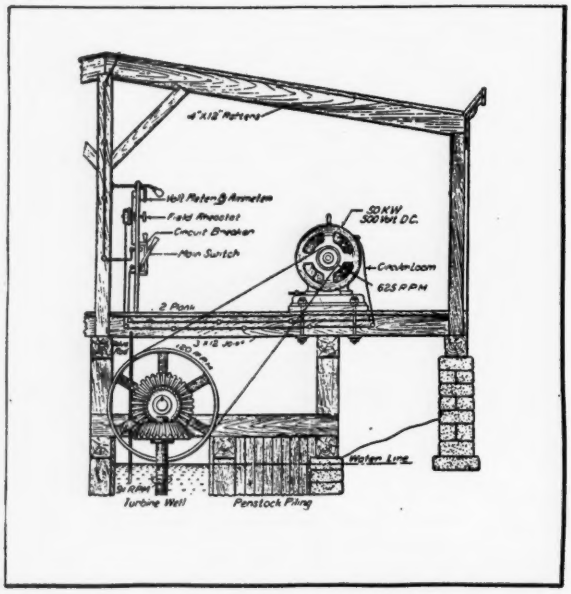

FIG. 2. ELEVATION OF POWER PLANT

To arrive at the most economical size of wire to get this 90 amperes over to the central powerhouse, you must realize that in any transmission there are 2 losses—the horsepower loss, due to line-drop, and the interest on the money invested in the wire. Obviously the wire in which the sum of these 2 losses is the least is the size we want.

For instance let us assume a line loss of 10 per cent or 5 kw. As a kilowatt is worth roughly $20 a year, the power loss would then be 5 kilowatt × $20, or $100. Figuring the wire for this loss, we use the well-known wiring formula: Circular mils = 10.8× 2d+A÷V, where V is the drop in volts, A the amperes, 10.8 the resistance of a mil-foot of copper wire, and 2d twice the distance in feet.

This gives 101,000 circular mils, or No. 1 wire, weighing 319 lb. per 1000 ft. The total weight would then be 900 lb., which at 20c a pound would amount to $180 and the interest on this at 12 per cent would be $21. You see, the interest is taken at what the same capital is worth on manufacturing account to the works, not at 6 per cent, the amount it would command in a bank. So the total loss per year for this size wire would be $121.

Suppose that we halve the power loss and double the size of wire to No. 4-0. The yearly power loss would then be $50 and the interest loss $42, making the total $92, a saving of $29 a year. But it would involve heavier poles, heavier bracing, more construction expense and would double the drain on the amount of money the works cared to spend on the plant, so that the $29 stood in good chance of being wiped out. As we already had in stock over 1500 ft. of bare No. 0 which might never otherwise be used, the whole line was put up in this size—The Operative Miller.

TEMPERATURE AND RESISTANCE OF ELECTRICAL CONDUCTOR

By J. H. Blakey

IT is a theory admitted by the great majority of electricians that the resistance which metals offer to the passage of an electric current is due to the heat existing in them. It is certainly admitted that in diminishing the temperature the resistance of the conductor is also diminished, the absolute zero of temperature being considered as a sort of critical point from which to start, at which this resistance ceases altogether.

These theoretical data have just received striking confirmation in the results of some experiments which are made the subject of a communication to L'Academie des Sciences Hollandais by their author, Mons. H. Kamerlingh Onnes. It may be remembered that this is the same scientist who in 1908 achieved scientific fame by liquefying helium at a temperature of 4.3 deg. absolute (—268.7 deg. C.); its critical temperature, or the temperature above which it is believed that no amount of pressure can reduce it to liquid form, being, according to the same authority, 5 deg. absolute.

By allowing helium to boil at a pressure of one centimeter, which is the one seventy-sixth part of an atmosphere, or about 1/5 lb. per square inch, a temperature of 3 deg. absolute—the lowest temperature yet known—has been reached. In dealing with temperatures as low as this it is of course difficult to find an element suitable for a thermometer, as nearly every known element solidifies at temperatures much higher.

In 1898 Ramsay and Travers discovered a rare gaseous element which exists in very small quantities in the atmosphere, which they called Krypton. This gas, although it liquefies at —152 deg. C. has never been solidified. Consequently it is the only element at present known which can be used for such extremely low temperatures.

By the aid of liquid helium, Mons. Onnes has been able to bring mercury to a temperature so low as to establish the fact that its resistance at 3 deg. above the absolute zero, which is —273 deg. C., is only the one ten-millionth part of its resistance at 0 deg. C. Thus it would appear to be possible by means of metal conductors deprived of their electrical resistance to construct a coil of fine wire capable of being charged by currents of enormous power, which would result in creating magnetic fields whose intensity would be astoundingly higher than any yet known.

PRACTICAL MATHEMATICS

Powers of Numbers; Extracting the Square and the Cube Root

INVOLUTION or raising numbers to higher powers is the process of multiplying a number by itself a given number of times. The number is called the root or first power and the products are called powers. The second power is generally known as the square of a number and the third power the cube of a number.

Powers of numbers are designated by an index or exponent, which is a small figure at the righthand side and a little above the number; for example, 5 squared would be indicated by $5^2 = 5 \times 5 = 25$; 6 cube or 6 raised to the third power, $6^3 = 6 \times 6 \times 6 = 216$.

To multiply 2 or more powers of the same number together add the exponent; for example, $2^2 \times 2^3 = 2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$. To divide the power of one number by another, subtract the exponent of the divisor from that of the dividend; example, $2^3 \div 2^2 = 2^1$ or 2.

Extracting the Square Root

EXTRACTING the root of a number is the inverse operation of raising a number to a higher power. The square root is indicated by the radical sign $\sqrt{\ }$; $\sqrt{24}$ would be read square root of 24. The cube root is indicated by the radical and exponent 3, thus, $\sqrt[3]{\ }$; $\sqrt[3]{1728}$ is read, cube root of 1728.

To extract the square root: Point off the given number into periods of 2 places each, beginning with the units. If there are decimals, point them off likewise, beginning at the decimal point and supplying as many ciphers as may be needed.

What is the square root of 14,400? For operation see Fig. 1. Following the rule we first point off the number into periods of 2 figures each as indicated.

Find the greatest number whose square is not greater than the first lefthand period. As the first period is figure 1, it is evident that 1 is the largest number we can use, so it is placed as the first figure of the quotient. We then subtract its square ($1^2 = 1$) from the lefthand period and bring down the next period, 44, for a dividend. Double the first figure of the quotient for a partial divisor, which equals 2, and find how many times the latter is contained in the dividend exclusive of the righthand figure, which is twice, and set the figure representing the number of times as the second figure in the quotient; we also annex it to the right of the partial divisor forming the complete divisor 22.

Multiply this divisor by the second figure in the quotient and subtract the product from the dividend. To the remainder bring down the next period which consists of ciphers. As there is no remainder we annex a cipher to the quotient, giving 120 as the square root of 14,400.

If there was a remainder or if the last period was a whole number we would have proceeded as before; in each case doubling the figures in the root already found to obtain the trial divisor. Should the product of the second figure in the root by the completed divisor be greater than the dividend, erase the second figure from both the quotient and from the divisor and substitute the next smaller figure, or one small enough to make the product of the lefthand figure of the root by the divisor less than or equal to the dividend.

Instead of 14,400 assume that the square root of 1.44 is required. In this example there is one period at the right of the decimal point and one period to the left of the decimal point. The operation would be the same as shown in Fig. 1, with the exception that the period containing the syphers is omitted. The position of the decimal point in the quotient or root is determined by the number of periods to the left of the decimal place in the number of which the root is extracted; the number of digits to the left of the decimal point in the root is equal to the number of periods. It should be noted that the lefthand period may contain but one figure.

Extract the square root of 298.5984. For operation see Fig. 2. As there are 2 periods left of the decimal point in the original dividend the root will contain 2 digits to the left of the decimal place.

Extracting the Cube Root

EXTRACT the cube root of 1728. For operation see Fig. 3. To extract the cube root, point off the number into periods of 3 figures each beginning at the righthand units place. Point off decimal places in periods of 3 figures from the decimal point. In this example there are no decimal places so that the number divides into 2 periods to the left of the decimal place. We next find the greatest cube that does not exceed the lefthand period, which in this

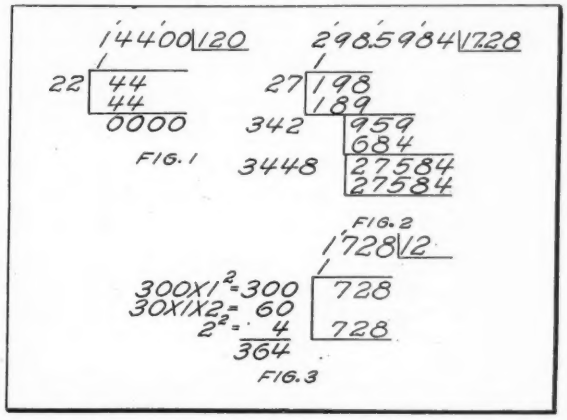

FIG. 1. PROCESS OF EXTRACTING THE SQUARE ROOT OF 14400
FIG. 2. OPERATION FOR EXTRACTING THE SQUARE ROOT OF 298.5984
FIG. 3. EXTRACTING THE CUBE ROOT OF 1728

example is 1 as $1^3 = 1$. Write its root as the first figure in the required root. Subtract the cube from the lefthand period and to the remainder bring down the next period for a dividend. In this example there is no remainder so we bring down 728.

Square the first figure of the root; multiply by 300, which equals 300 as shown, and divide the product into the dividend for a trial divisor; write the quotient (2) after the first figure of the root as a trial second figure.

Complete the divisor by adding to 300 times the square of the first figures, 30 times the product of the first by the second figure, (60) and the square of the second figure which equals 4. Multiply this divisor by the second figure of the root and subtract

the product from the remainder. There is no remainder so the cube root is 12.

Should the product be greater than the remainder, the last figure of the root and the complete divisor are too large; substitute for the last figure of the root the next smaller digit, correct the trial divisor accordingly and complete the operation as before.

To the remainder bring down the next period and proceed as before to find the third figure of the root, that is, square the 2 figures of the root already found and multiply by 300 for a trial divisor, etc.

If at any time the trial divisor is greater than the dividend, bring down another period of 3 figures and place 0 in the root and proceed. The cube root of a number will contain as many figures to the left of the decimal point as there are periods of 3 at the left of the decimal point in the number.

Find the cube root of 1,906,624. For operation see Fig. 4. As this example contains one more period than the previous example it involves 2 sets of operations. They are similar except that instead of using the product of 300 times the square of the first figures of the root, we use the square of the part of the root already formed or 12^2, and in like manner add to

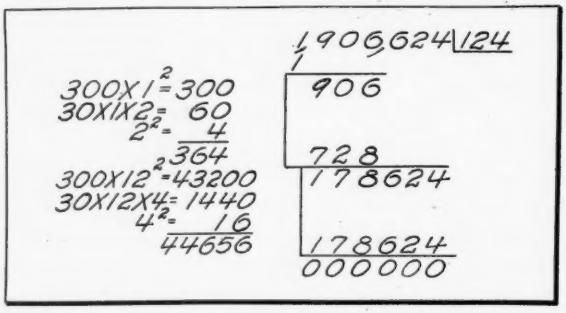

FIG. 4. EXTRACTING THE CUBE ROOT OF 1,906,624

the trial divisor, not 30 times the product of the first by the second figure but the product of the part of the root already found, which is 12, by 4 the third figure.

The fourth root of any number is the square root of the square root; the sixth root is the cube root of the square root. Other roots involve the use of logarithms and will be dealt with in a subsequent article.

IN AN ADDRESS before the Irrigation Congress at Chicago, Professor Gardner S. Williams, of the University of Michigan, estimated as follows the waterpower available in the rivers which drain the great lakes: St. Mary's River, 170,000 hp.; Niagara River, 7,000,000 hp.; St. Lawrence River, 6,500,000 hp The sum of these available outputs is equivalent to one-fourth the power which might be developed from the total coal production of the United States as mined at the present rate. Professor Williams also commented on the claims made by the navigation interests and others, that the diversion of water through the Chicago Drainage Canal has lowered the Michigan-Huron lake level. He pointed out that in the lowering of levels and destruction of harbors navigation is itself a most active agent for when connecting channels, like the St. Clair and Detroit Rivers, are dredged to deepen them the increased flow through the new opening may discharge water enough to depress the upper lake level and reduce the dredged channel to its former depth. The Michigan-Huron surface has already been lowered 8 in. in this way.—Steam.

COMMERCIAL VALUE OF THE AIR LIFT *

By F. S. MILLER

WELLS may be grouped under 2 general headings, gravel and rock. Under the first are included sand and quicksand wells. One of the first things to be determined is the kind and location of the strainer. The best strainer for air lift work from beds of gravel or coarse sand is a perforated strainer with openings large enough to admit the fine sand. Then with the 20th century method of sealing and back-blowing a well, the sand can be drawn into and pumped out of the well and the coarser material gradually collected around the outside of the strainer in sufficient quantities to offer an area large enough so that the water percolating through will not have the velocity to carry the sand with it. The output of wells of this kind can often be increased, if not doubled, by back-blowing.

The writer has just finished developing a well of this kind that had 1000 ½-in. holes in a strainer located in mud and gravel. With 2 or 3 days' blowing we increased the discharge from 200 to 370 gal. a minute, thus practically doubling the value of the well.

Many wells that have been driven with the intention of using a deep well pump, or in which perhaps a deep well pump has been used for years, are equipped with a strainer having fine slots, whose purpose is to keep the sand out of the well to protect the working barrel and valves. These wells, it will be found, have greatly diminished in supply, which 9 times out of 10 is caused by the sand choking up the openings in the strainer, and the treatment of back-blowing will put the well back to its original capacity.

The question is often asked, Will not the well choke up again? But suppose it does; it is only a question of a few moments' manipulation of the valves already installed with the 20th century lift to back-blow it and clean the strainer. Thus the clogging up does not become a matter of serious consideration.

In studying the supply of water secured from gravel or sand, it is always well to know whether the well has been driven into a pocket or live strata. If the former, and a large supply of water is to be pumped, then it may soon be exhausted; but if the wells are in live water strata of sand or gravel, which are renewed from a stream of water or water shed, then the supply is practically inexhaustible, and it is a question of getting the water into the well.

Rock Wells

ROCK wells are of a more uniform supply, and the record of wells in the same strata will give a guide to go by, taking into consideration the topography of the country. Although back-blowing will clean out the rock crevices in the seamy rocks, it rarely causes so much of an increase as in gravel or sand wells.

About the most deceitful well in the business is the flowing well. We have often heard customers state that they have a very strong well because it flows, and that it has a shut-in pressure of several pounds. The fact that the well flows does not indicate that it is a strong well, for the strata may be so tight that the relieving of the head will not materially increase the yield, and more often overflowing wells may be pulled as far as possible with air without materially increasing their supply.

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*Abstract of paper read before the Middle States Ice Producers' Exchange, Louisville, Ky.

On the other hand, if it is a rock well full of crevices or sand rock, the yield will be almost unlimited. Such well should be carefully studied by getting the data from neighboring wells, or by testing them out.

In order to get an intelligent estimate for pumping with the air lift, the following data are required:

Number of wells. Depth.
Diameter of casing. Depth of casing.
If bore reduced, at what depth.
Character and depth of water strata.
If strainer, give description and depth.
Static head. Estimated drop.
Elevation. Total lift.
Horizontal discharge (gravity or pressure).
Pumping submergence.
Gallons per minute required.

Operation of the Air Lift

IT is well to call attention to the fact that in low submergence, a larger sized eduction pipe and pump should be used than when working with a high pressure; first, on account of using low pressure, less initial velocity is secured, and second a greater volume of air must be used to pump the same amount of water. For instance, for pumping 200 gal. of water per minute with 60 to 65 per cent submergence, on lifts up to 100 ft., a 4-in. pump and discharge pipe is of ample capacity, while with a submergence of 35 to 40 per cent at least a 4½-in. pump and pipe should be used. With lifts of 150 ft. and above, it is an advantage to enlarge an eduction pipe to take care of the expansion of the air as it travels with the water to the point of discharge, a safe rule being expansion of one size of every 150 ft. of discharge line.

Care should always be taken to secure a large enough air line to reduce the friction. While a 1¼-in. air line would be large enough to use with a 3-in. pump under conditions of 80 to 100 ft. lift, it would be too small for the same pump with a 200-ft. lift, for the well should have a larger air pipe on account of having to carry more air to do the work. It sometimes happens, however, that the size of the well will not admit the use of a larger size air line. Then a higher pressure will have to be used to force the amount of air through at a loss of efficiency.

Compressed air does its most efficient work lifting water perpendicularly and without change of direction until the desired lift has been accomplished. Care must always be taken in these installations, if the water comes into the well above the pump, to see that there is enough area left for the down flow of the water between the walls of the well and the outside of the pump.

In regard to horizontal discharge, it is always best to arrange the plant to discharge under an umbrella separator and take care of the horizontal flow by gravity. If this cannot be done, a water ell can be used, but should be carried up high enough to give the gravity flow and the horizontal pipe enlarged sufficient to permit the air passing to the top of the pipe and flowing with the water, without having to do any work.

It is sometimes necessary to pump through a long horizontal line, where the point of discharge is higher than the well top. When this cannot be avoided use long radius bends, and as few as possible, and add a percentage to the lift in figuring the amount of air needed. So much greater economy can be secured with the straight lift and separator that this installation should always be used wherever possible.

Compressed air, when expanding, absorbs heat from different substances it comes in contact with, so that the use of air to lift water, when properly applied, tends to cause a drop in temperature. This is especially noticeable in water of high temperature.

In the ordinary air lift, where a large volume of air is used so fast that it does not have time to lose the heat of compression, or where the air is used in plugs and does not come in contact with all the water, this effect may not be secured. With the 20th Century lift, however, where a small amount of air is used, a perfect expansion takes place, and the particles of air and water are thoroughly broken up and mixed together, and the expanding air comes in contact with all the water, causing a marked reduction in waters of high temperature.

In the manufacturing of ice, you are of course perfectly aware that a saving in power or increase in output is secured by the lowering of the temperature of the water a few degrees. Hence, the use of a properly installed air lift, especially in the South where the water temperatures are higher, not only produces the amount of water required at a less cost, but puts the water in condition to do more work.

Cost of Pumping with Compressed Air

WE will take the following example:

Amount of water to be pumped per minute	100 gal.
Total lift	60 ft.
Submergence	90 ft.
Actual free air required per minute	33 cu. ft.
Working pressure, including air friction	45 lb.
I. hp. in steam cylinder	4.2
Steam consumption in straight line air compressors	45 lb. of steam per 1 hp.
Evaporation of water per pound of coal	7
Pounds of steam required per hour	189
Pounds of coal required per hour	27
Cost of coal per ton	$2.00
Cost of coal per pound	1c
Fuel cost per hour	27c
Gallons pumped per hour	6000
Fuel cost per thousand gallons	4.5c

Another thing to be taken into consideration is the reduction of up-keep, as the air lift removes all chance of repairs in the well and places the only machinery used in the power plant under the eye of the engineer.

PROFESSOR DR. CONRAD MATSCHOSS, dozent of the Royal Technical High School of Charlottenburg, Berlin, started August 10 for the United States to make a study of the method of technical education in America. He comes as the official representative of the Verein Deutscher Ingenieure accredited to the American Society of Mechanical Engineers, which is to arrange for Dr. Matschoss' tour. One of the most important questions in Germany today appears to be how to educate engineers so that they will be more immediately available after graduation for practical work. It is thought that the system in Germany produces better theoretical engineers than the American, but they lack versatility and ability to adapt themselves, as do the Americans. While here Dr. Matschoss is to discuss with the American Society the details of the proposed joint meeting in Germany next year. There are indications even now of elaborate planning for the meeting, including a trip through the industrial sections of Germany, arrangements which augur well for the success of the meeting. Incidentally it is thought that Dr. Matschoss may make a report at the meeting of his investigations in this country.—The Iron Age.

FOREIGN DEVELOPMENT IN THE POWER PLANT FIELD

By J. H. Blakey

ELECTROLYTIC LIGHTNING CONDUCTORS

BULLETIN de la Compagnie Thomson-Houston for May contains a detailed study of electrolytic lightning conductors. The conductors constructed by the Thomson-Houston Company are composed of electrodes of aluminum covered with a film of hydroxide of aluminum, and bathing in a suitable electrolyte.

If an electric tension is applied to these electrodes, the element manifests opposing properties, according as this tension is inferior or superior to a determined critical value. Below this critical tension, the element opposes a considerable resistance to the current, and above it the resistance becomes negligible, it is only that of the electrolyte.

The aluminum electrodes have the form of cones and are set at intervals of about 0.4 in. (10 millimeters). They constitute complete electrolytic couples, mounted

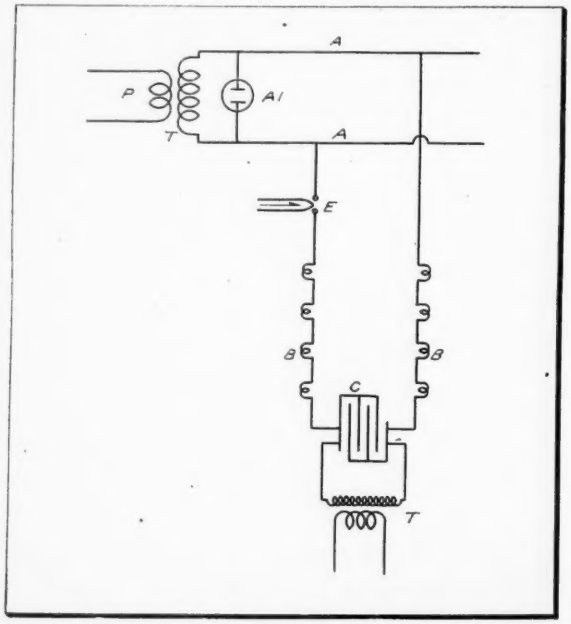


DIAGRAM TO ILLUSTRATE THE TESTING OF AN ELECTROLYTIC LIGHTNING CONDUCTOR

in series; and the whole arrangement is immersed in a vat filled with oil; the electrolyte, more dense than the oil, rests at the bottom of the vat, and its evaporation is prevented. The number of elements is proportional to the tension limit proposed, say from 1000 to 140,000 volts. The film, pierced by the discharge, immediately reforms itself automatically, and the author studies the conditions of its dissolution and reconstruction.

This apparatus has been subjected to oscillographic analysis, under the conditions indicated in the illustration. The apparatus used for high tensions is a 5-kw. transformer, the primary tension being 110 volts and the secondary tension 2200. To produce these high tensions over the line A, A condenser C is used, which a transformer T, allows to be changed to 30,000 volts. By means of resistance bobbins B the frequency of the oscillating discharge can be brought up to 1000 periods per second. When the tension at the faces of the condenser is sufficient to produce an arc at the sparker E, an oscillating discharge is sent to the line and to the transformer T. In passing through a certain number of electrolytic elements A1, acting as shunt wires on the line, the high tensions are absorbed. By means of the oscillograph high tensions are registered with or without the lightning conductor, and a complete record can be made of the exact effect of the apparatus, and the number of elements required determined upon accordingly.

HIGH TENSION ELECTRICAL TRANSMISSION

IN L'Industria of May 26 and June 2 and 9, M. C. D. Salda studies the characteristics of lines for the transmission of electrical power having tensions exceeding 100,000 volts.

In these lines insulation has been made certain by the employment of insulators in a chain, that is, one beyond another. The transformers are in an oil bath, and the terminals for the conductors coming out of them are generally of the type of condensers, the conductor being incased in cylindrical tubes composed alternately of insulation and brass, of decreasing lengths.

The author considers the different attachments and accessories necessary in installing lines for very high tension. He states that a line suitable for a tension of 44,000 volts will have 6 conductors of a total section of 127 square millimeters, whereas a line to carry 110,000 volts will require conductors having a section of only 55 square millimeters.

THICK LUBRICATING GREASE

EMPLOYMENT of thick greases as lubrication has recently become general, particularly since the appearance of small greasers with regulable discharge, by the action of a screw or piston in a cylinder. From this has resulted the putting on the market of numerous types of lubricators and an interesting technology of matters lubricatory.

In the Revue Generale de Chimie for June, M. R. Vallier examines the industrial processes for the production of various heavy greases.

He studies at first the thick greases without soap, consisting, for the greater part, of mixtures extremely variable, according to the origin and the commercial movements of the diverse constituents. In support of this assertion, the author gives the ingredients of various mixtures employed for wagon axles, printing machines, piston rods, belts, cast-iron gearing, etc.

In the second part the author treats of the heavy greases which are partially or totally saponified, and especially those having a base of animal fat. This fat is first transformed into granular soap, then it is pulverized and dissolved in variable proportions of mineral oil, according to the consistency which it is desired to obtain. Some formulas which are particularly recommended give products which are perfectly homogeneous, and which, even under a microscope, magnifying 250 diameters, do not show any signs of insoluble crystals.

Some heavy soda greases, prepared by mixing fatty matters with Solvay* soda, giving good products for locomotives and wagons. With regard to palm oil greases, the author gives a comparative table of the formulas employed in England, Belgium and the United States, and after having cited various patented compounds, he concluded with a study of those thick greases which have a basis of metallic soap. This branch of the subject is, however, purely academic, at least at present; these last named greases being so high priced as to prohibit their employment for any industrial purpose.

THE LOW EXPLOSION MOTOR

THE low gasoline motor differs from all other motors on the market in its method of feeding the explosive gas. It has now been for some time on trial in France and gives excellent results; it is extremely light and has a very high thermal efficiency.

The base of the cylinder A of this motor is surmounted by a cooling chamber B, into which the gasoline is driven by a pump C. The gasoline, coming in contact with the hot base of the cylinder, vaporises even under heavy pressure; after which it is conducted by a tube D above the piston of the pump C, which it drives downwards, compressing the spring H and sending into B a new charge of gasoline, until the piston opening the entrance of the passage E allows it to pass into the cylinder A.

The motor is regulated in such a way that the cylinder A contains at this moment a charge of fresh air compressed to about 500 lb. per sq. in. (35 kilograms per square centimeter) and that the piston is at the beginning of the expansion stroke.

The gas mixes with this air and explodes on coming in contact with it; the regulating device provides that it shall continue to pour into the cylinder the greater part of the expansion stroke, and to insure its combustion maintains in the cylinder an ignition spark during the whole of the time of the admission of the gas. Expansion ended, the escape and the admission of a new cylinder full of fresh air is effected as in other motors. The duration of the flow of the gas is regulated by an oscillating valve F: a throttle valve G allows the reduction of supply from the chamber B.

The light weight of the motor is due principally to the suppression of the carburettor and valves for the distribution of gas and air; the increase of efficiency is explained by the very strong compression employed and by the utilization of a considerable portion of the waste heat for the evaporation of the gasoline.

PHENOMENA OF LIGHTNING †

THE author describes some new phenomena which were observed on the 3rd of May, during the storm which broke over Athens and Piraens.

The phenomena related do not seem to constitute a veritable lightning stroke, but they lead to the belief that, in conditions that remain to be discovered, there is produced, in a certain direction, a kind of electric wind or strongly ionized current of air. This hypothesis explains very satisfactorily the greater part of the electrical phenomena mentioned in this communication, as well as many others which have remained till now without any possible explanation.

*The Solvay process is a method of making soda from common salt, based on the sparing solubility of sodium bicarbonate, which is precipitated when carbon dioxide is passed into strongly ammoniacal brine, leaving sal-ammoniac in solution. The bicarbonate is converted into carbonate by calcining. This process was named after Ernest Solvay of Belgium, the inventor.

†Note by M. C. Maltezos to the French Academy of Sciences.

TAR OILS FOR HEATING AND POWER

AFTER having described summarily an insallation for the utilization of tar oils for the heating of a metallurgical furnace, in an article in Stahluno Eisen of May 9, M. Hausenfelder gives prominence to the advantage which may result, for German industry, from the substitution in certain cases of these furnaces for the consumption of tar oil in place of the coal and gasoline furnaces now in use.

The author shows, by a calculation, that the expenses of heating, including interest on the cost of the installation and other incidentals, are less with tar oil burners, notably in the case of furnaces for heating iron, steel crucible furnaces, forges, muffle furnaces, steel reduction furnaces, crucible furnaces for the fusion of tungsten and furnaces for casting copper.

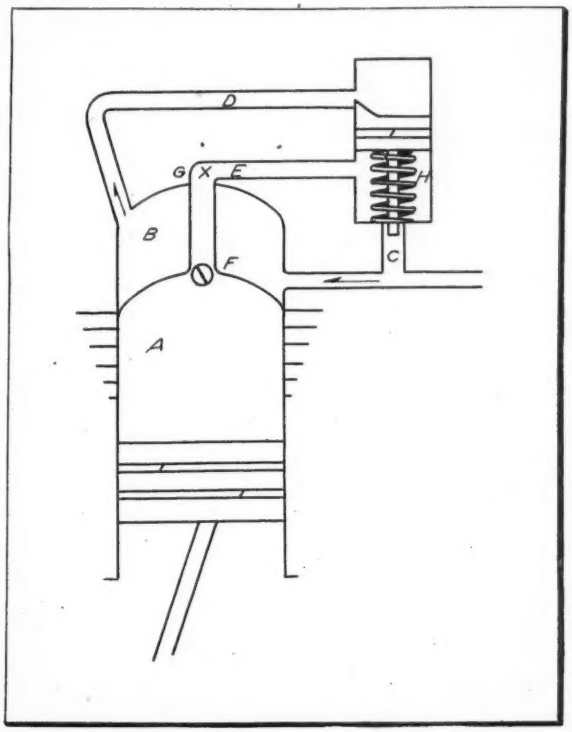


DIAGRAM TO ILLUSTRATE THE LOW EXPLOSION MOTOR

These burners may also replace the powerful blow pipes which are used for lighting blast furnaces. The same oils are also employed in combustion motors, but the author does not believe in the practicability of the direct use of brown tar (wood tar) oils for this purpose, on account of the irregularity of their composition and their insufficient fluidity when cold.

EVERY GASOLINE ENGINE needs a friction clutch pulley. An engine so equipped can be started easily; then, when it comes up to speed, the clutch may be thrown in and the load applied gradually. This method of starting is much easier on the belts and on all the machinery. A gas engine usually starts up quickly and if the load is belted to a fixed pulley it starts with a jerk. This is not true with steam engines, because they can be started as slowly as the operator desires, but with the quick starting gas engine a friction clutch pulley is essential.—Gas Review.

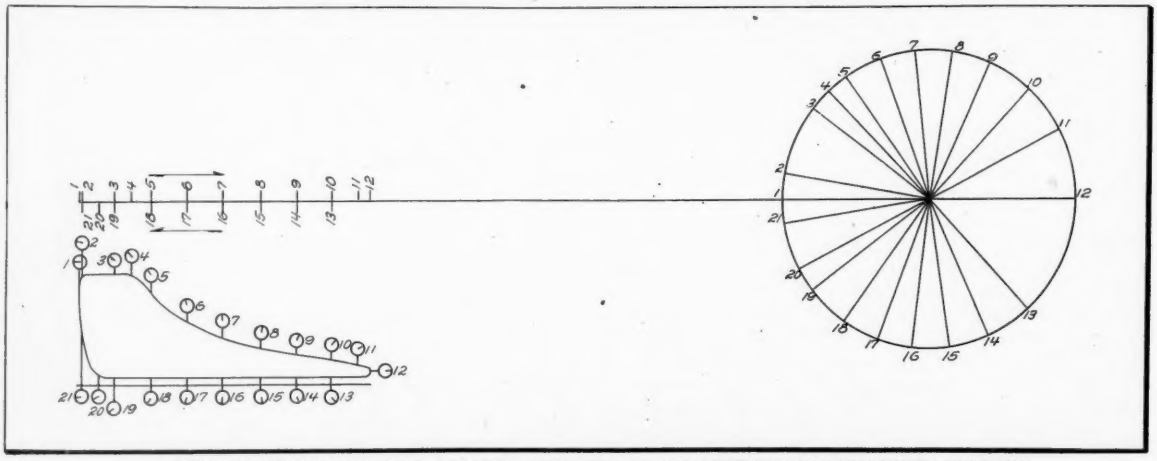
LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

CRANK POSITION AND INDICATOR DIAGRAM

THE sketch shows an indicator diagram taken from the high-pressure cylinder of a horizontal engine. The card is divided into a number of parts, at points on the diagram about where cut-off, etc., occurs, and the same number of divisions are laid out above, on a line the length of which is exactly the same as the length of the diagram and the corresponding points numbered. Those numbered above the line representing the forward stroke, and those below the line, the return stroke.

A circle representing the path of the crank pin, and the length from 1 on line to 1 on circle represents length of connecting rod, 5½ cranks. The different parts on the line numbered from 1 to 12 are laid out on upper part of the circle and parts numbered 12 to 21, on the lower part, each, of course, at the distance of 5½ cranks. Radial lines representing crank positions are then drawn to each of the points on circle.



GRAPHIC EXPLANATION OF RELATION BETWEEN CRANK POSITION AND INDICATOR DIAGRAM

Small circles are drawn at each division of the card and a radial line drawn in each represents the position of the crank at that point.

At 1 the crank is on head end center. At 2 it will be seen that the lead is late and that the crank has moved ahead quite a distance before full pressure of steam was realized in the cylinder.

At about 4 the cutoff occurs, and shows corresponding position of crank.

At 7 the piston has traveled ½ stroke, but the position of the crank is a few degrees less than 90 on account of angularity of connecting rod.

At 11 exhaust valve opens for release; 12 shows the crank end center, and 20 shows position of crank when exhaust valve closes for compression.

I think the above gives a very clear idea of the crank positions and am very sure it will be a great benefit to those studying indicator diagrams. L. E. T

QUICK BOILER CLEANING

READING so much of coal oil, graphite, etc., as scale exterminators, recalls to the writer an efficient, although not approved, method he once used to clean a badly scaled boiler. The boiler in question was an old return tubular and had been in service about 20 yr. The boiler inspector having reduced the pressure allowed, to 40 lb., which was insufficient to carry the load, it was decided to remove the old boiler and install a new one in its place.

As the old boiler was to be junked, I thought it no crime to try an experiment, which I would not likely have done had the boiler ever been expected to be used as a steam generator again. The water was all drained out and the manholes closed up. From a nearby stable I procured a lot of straw, cornstalks and refuse, which was stuffed into the furnace and combustion chamber, loosely, so as to allow free passage for the draft. When all was ready, the damper was opened wide and with feeling that he was doing something that was not just right, the writer touched a match to the straw in the furnace. As the fire burned up, a cracking noise was heard from the inside of the old tub, which gradually died down as the fire burned low.

Some attributed the noise to unequal expansion of the plates as the top of the boiler was barely warm, while the bottom of the boiler was pretty hot, but I am of the opinion that it was the scale cracking off the plates, as when the boiler was opened, 3 wheelbarrow loads of scale were taken out. The scale was ⅜ in. thick in some places, and before the roasting it was all a man could do to cut a bucketful loose in a day with a hammer and chisel, but after, all that didn't come off of its own accord, could easily be jarred off with a light hammer blow.

After this ordeal the boiler was subjected to a hydrostatic pressure of 140 lb., and not a sign of distress came to light, not even a leaking rivet or seam. The boiler was not junked however, but was installed in a greenhouse for low-pressure steam heating, and is today carrying 25 lb. While I would not recommend this method of cleaning boilers, I feel safe in saying that this one was not injured in the least.

I have used coal oil with fairly good results. My method is to pour the oil in the bottom of the boiler just before filling up, and as the water rises, the oil will deposit itself on the plates and tubes. For a 60-hp. boiler, I used ½ gal. at each cleaning, cleaned every week, and after about 4 months, the boiler was practically free from scale, although before I began using the kerosene it was pretty badly scaled. I have tried this treatment on other boilers with indifferent success, and it seems not to effect any two alike.

H. R. S.

CURE FOR HOT BEARINGS

WHEN the crank pin or main journal gives trouble it is from some cause and usually due to lack of lubrication or some abrasive has gotten into the bearing. Yet there are 2 other causes for a hot bearing. First, it may be set up too tight causing excessive friction, and, on the other hand, a crank pin is often caused to run hot by having too much play, and the shock of the piston will cause the pin to heat up, especially so where the engine has not much compression.

When the crank pin becomes cut and scored up the best remedy is to file the pin carefully with a fine cut file first filing in direction of the circle, when smooth, draw file lengthwise around, and when this has been done put a fine piece of emery cloth on a strip of wood and dress the surface in the direction of the first filing and when this has been done take a strip of very fine emery cloth and pull it around the pin when the bearing will be ready to assemble.

In many cases the bearing will run hot at first but you can remedy this by using a lubricant made of engine oil, white lead and ordinary ammonia, commonly called house ammonia. You will be surprised how you can work down a bearing on a large ammonia compressor that had to be kept going. I have used this method and the results are fine and when cooled down you will have no more trouble.

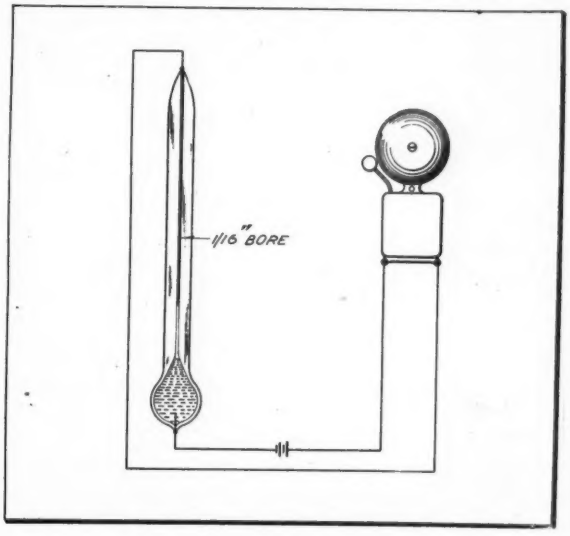
The ammonia, in its evaporation, will carry off much of the heat generated and the lead forms a paste which carries away the particles from the abrasion. This will work in the most troublesome bearing. I have cooled down crank pins that had been running hot for hours by this method. C. R. McGahey.

HOME-MADE THERMOSTAT AND HOT BEARING ALARM

NEARLY every engineer has some bearings that are hard to get at and consequently they do not get the attention that they should. To have a reliable alarm to give warning in case such a bearing should run hot would relieve one of much anxiety and useless steps. Such an alarm can easily and cheaply be constructed by any engineer, and all that is required is a short piece of glass tubing, an ounce of mercury, 2 cells of dry battery, a few feet of insulated copper wire and an ordinary electric door bell or buzzer.

Procure, from the drug store, a piece of glass tube about 6 in. long and 1/16-in. bore. Insert a short piece of bare copper wire into one end of the tube and let it extend in about ½ in. Now, hold the tube over the flame of an ordinary alcohol lamp until the glass has fused around the wire. Still holding it in the flame, blow lightly into the other end and form a small bulb as a receptacle for the mercury.

Now comes the hardest job, that of loading the mercury into the tube, as it cannot be poured on account of the entrapped air. I find that the quickest way is to attach a piece of rubber tubing, such as chemists use, to the tube and suck the air out, or better still, attach the tube to the condenser or vacuum pump. When the air is exhausted, squeeze the rubber tube together with the fingers, to prevent the air from



HOT BEARING ALARM

rushing into the vacuum, and immerse the end into the mercury before attempting to pour it in. The tube should be filled about ¼ full. Now, with a standard thermometer as a check, heat the tube to the temperature at which you wish the alarm to be given, and put another wire into the open end and let it extend down to the level of the mercury; then seal the tube as you did the other end.

The thermostat is now made and is ready to connect up. It may be attached to the bearing housing in any way you may prefer, but it should be as near the bearing surface as possible. Connect the terminals of the thermostat to an electric bell, with the batteries in series, and you need worry no more about that troublesome bearing. If you already have a circuit breaker alarm or other alarm system, this may be connected to it also, but don't try to use 110 volts, as you would likely make a mercury vapor lamp of your thermostat and burn out the contact wires.

This form of thermostat is superior to the spring expansion type, as vibration does not effect it in the least, while with the other it is impossible to adjust the point of alarm if there is the least vibration. If a varying alarm point is desired, the top of the tube need not be sealed, but some means must be employed to hold the upper wire in place. H. R. Siders.

TROUBLE IN A PUMPING PLANT

IN compliance with Mr. Wilhelmsen's request in the issue of September 1, I submit the following reason for the hot bearing on his centrifugal pump. The cause may be due to sand or grit in the water, being washed into the bearing, as it may leak some around the shaft, when the water from the discharge pipe is flowing back to the river, the pump being stopped. When raising the water and starting again, this would work the sand out and make the bearing run cool.

I had an experience with a pump of about the same capacity. It had only packing boxes in both suction elbows, the bearings being independent of the pump. If the packing leaked when the pump was stopped and was tightened up until it stopped leaking, it would heat up on running, because tightening up the packing caught some of the sand that was in the water, which made it run hot. It was then decided to tighten up the packing while the pump was running, and we had no more trouble with hot bearings. L. K.

PIPE DRIPS

FIGURE 1 shows an engine which was set 150 ft. from the boilers and for this reason, and because of condensation in the long length of pipe, the drip valves 2 and 3 were always left open blowing to the open air, having no trap. This particular engine had a shaft governor but out of order, so the engine was

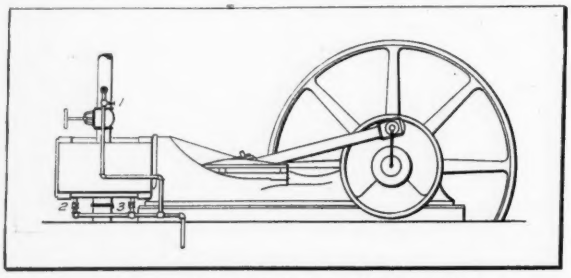


FIG. 1. ENGINE WITH DRIP CONNECTIONS

always run on the throttle as near as possible for 120 r.p.m. My attention was called to the fact that when all of the drips 1, 2 and 3 were open the engine would make 20 more revolutions or 140 r.p.m. When No. 1 was open the engine would immediately speed up and promptly when No. 1 was shut off it would come down to 120. A glance at these drips will explain the whole thing, as when No. 1 is blowing into the drip main it creates a resistance for the free flow of steam

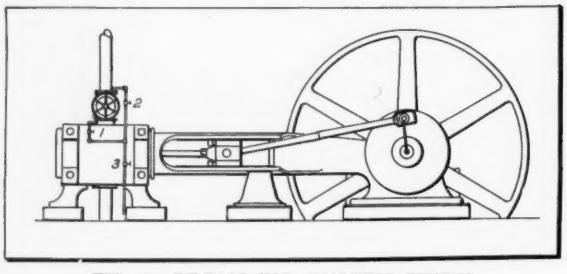


FIG. 2. BY-PASS FOR STARTING ENGINE

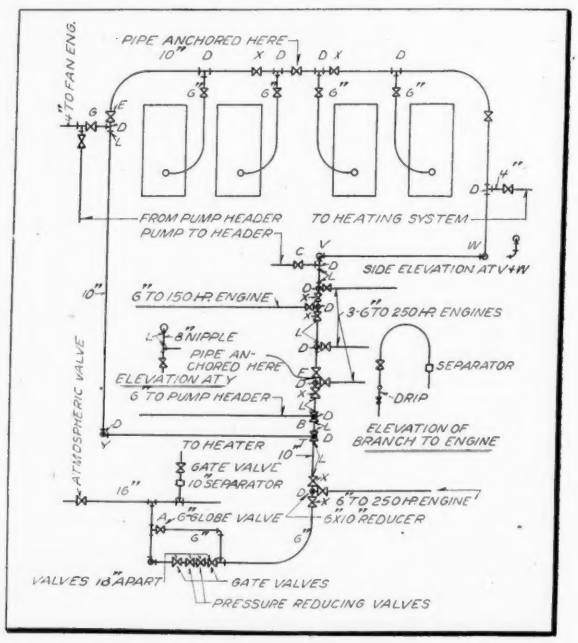
from 2 and 3 and consequently maintains the pressure in the cylinder and acts really to keep the condensation from blowing out of the cylinder.

Figure 2 shows some drip pipes, No. 2 is to drain the main and is ¾-in. No. 1 is ⅜-in. and is used to relieve the pressure from the valves quickly when throttle is shut also to warm up engine when No. 3 is shut. This is a different engine from that mentioned above but the principle as shown above is the same here, for instance, when No. 2 is open it will, in blowing down the ¾-in. main, back up the ⅜-in. pipe and start the engine notwithstanding that it has a friction load of 58 hp. and that No. 3 valve is also open with an open ended pipe, it simply shows the crowding effect of the steam in getting out of the drip pipes.

A. C. Waldron.

LOCATION OF VALVES IN STEAM PIPE

THE answers to my request for the ideas of engineers as to the proper number and location of valves in the steam piping system shown in the August 1 issue were read with much interest. I wish to say that both Mr. Robinson and Mr. Fischer have shown what I think is the proper number of valves except that in Mr. Fisher's diagram I would place a valve at either end of the boiler header. This steam system was designed by a consulting engineer and erected about 4 yr. ago. Although I do not know what the ideas of the designer were in regard to the units to be carried



STEAM PIPING SYSTEM SHOWING VALVES AS LOCATED BY DESIGNER OF PLANT

at one time, in the 3 yr. that I have known the plant 2 of the 250-hp. engines, and 3 of the boilers have carried the maximum load with ease, and except on dark days, and sometimes for a few hours at night, one engine carries the load.

I enclose herewith a sketch showing the piping and location of the valves as actually installed, and I think that there are 8 more valves than are necessary, which would cost at least $900, and consider those located at the points marked X as unnecessary. I would use 5 10-in., 3 6-in. and one reducing valve. These valves are all outside screw-and-yoke pattern, and all except those on the boiler branches are by-pass valves.

The branches to the engines are taken from the top of the header through a long sweep bend with a

gate valve on the branch next to the tee at the header, and a separator is located just above the throttle. There are short nipples at point marked Y between the ell and tee, and at point T between the angle valve and tee, also at points W and V, all of which have given trouble by leaking in the threads, and have been renewed.

This system is drained by a Holly gravity return system, which is connected to all points marked D, also bleeders are connected between the automatic stop valves and the gate valves on the branches to the boilers. As the piping was first installed the pump header was only connected to the main header at point marked B, but since that time a connection has been made to the other end of the pump header from point C, and also to the fan engine from the pump header, so that in case it is necessary to close valves E and F the pumps and fan engine will get steam through valve C with valves B and G closed. Automatic non-return valves that close against the header pressure only are installed on the boiler outlets. These valves will close in case of boiler failure, but not in case of steam pipe failure. The steam line is suspended from the ceiling by hangers about every 10 ft., and is anchored at points midway between Nos. 2 and 3 boilers, and between Nos. 3 and 4 engines. None of the gaskets in the line have ever leaked, but the line has leaked in the threads at points marked L. This I think must be caused by vibration, as the temperature of the room is constant, and the steam pressure steady.

These extra valves may have been advisable from the viewpoint of the designer, but I do not consider them necessary or of any advantages to the system, and it not only increased the cost, but also the weight of the line to be suspended, and makes a great many extra joints to give trouble.

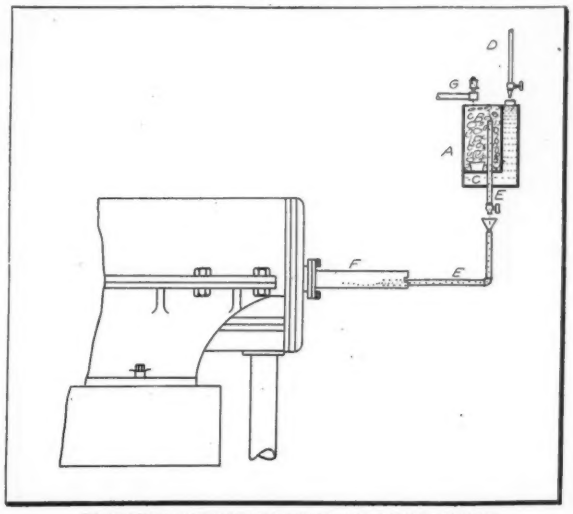
As this steam system was designed in the office of a well-known consulting engineer, I was curious to know if this great number of valves was considered advisable by other engineers, and if it made the line any more safe, and wish to thank those who answered my inquiry for their information.

J. C. Hawkins.

SOAPSUDS LUBRICATOR

ACCOMPANYING sketch is of a soapsuds lubricator for feeding soapsuds to an air compressor, compressing air to 90 or 100 lb. gage pressure. With a single-stage air compressor the temperature of the air after compression frequently reaches 450 to 500 deg. F.; this high temperature results in more or less carbon being deposited on the discharge valves and passages when ordinary cylinder oil is used, and trouble is often experienced in properly lubricating the air cylinder, especially is this the case where compressors are run at high speed and the temperature of intake air exceeds 80 deg., or where an inferior grade of oil is used. To overcome this trouble soapsuds has frequently been used as a lubricant instead of oil, with good results. The illustration herewith shows a novel way I have of feeding soapsuds into a cylinder provided with piston inlet valves and will be of interest to some engineers who are using machines of this kind and have experienced the trouble referred to above.

The device consists of a small, galvanized iron water tank A, about 7 in. long, 6 in. wide, and 12 in. deep. Inside of this tank is a smaller one, B, which is soldered to the large tank, and the bottom of which is 2 in. above the bottom of the large tank. In the bottom of the small tank are a number of ⅛-in. holes, shown at C. Soft brown soap is cut up in small pieces and put into tank B; water is then fed into the large tank through a ¼-in. pipe, D, and passing through small holes at C dissolves the soap and rises to the top of the ¼-in. pipe, E, through which it passes down into the inlet of the air compressor. The water is regulated at D, the small cock under the tank being left wide open. Just before shutting down the compressor, the water is turned off at D, and oil is fed into the small tank B from cup G, and the compressor is run with oil ½ hr. to prevent rust. Use soap that will sink in the water; otherwise small chips will float



SOAPSUDS LUBRICATOR FOR AIR COMPRESSOR

and pass down through pipe E. This is used on an Ingersoll-Sergeant compressor, 14 in. in diameter by 18-in. stroke, and when running at 150 r.p.m., with an air pressure of 90 lb., the water is fed at about 45 drops a minute, and no trouble is experienced in lubricating the compressor. Martin McGerry.

SODA AS BOILER COMPOUND

IN the October 15 issue, page 1053, I see an article by Fred L. Wagner, on Graphite as a Boiler Compound.

In the 90-hp. plant of which I have charge, I use nothing but common, plain sal soda. I have an old sugar scoop, 2 by 4 by 5¾ in. Each day I put 5 or 6 scoops of soda, which will amount to about 12 or 15 lb., in a pail and dissolve it, then I pour it in the well and pump it into the boiler.

The night man is instructed to blow down a gage or gage and a half of water each morning, while his steam is low, and I clean the boiler every third Sunday. In this system I do not vary, and I have no scale and very little mud.

I would give the following caution, however, to anyone who is bothered with oil in their boilers—in using soda it is liable to cause you trouble if used in the quantities I have stated above; take only half the amount, also when using the returns from your heating system. J. B. De Kalb.

IT IS EASIER for a woman to change her mind than for a man to change his luck.

THERE ARE SO FEW things in this world worth having that it pays to go after them.

Successful Kinks From The Plant

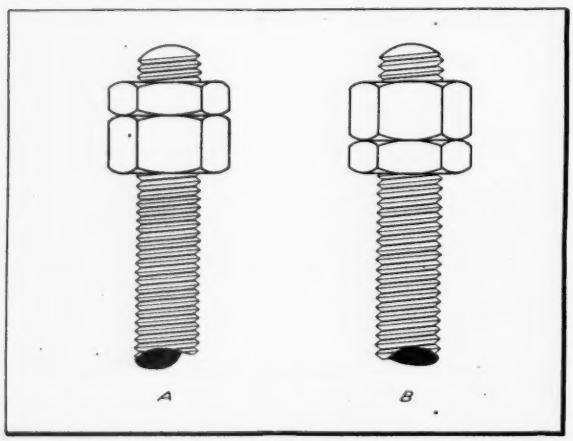
For Saving Time, Work and Trouble

Lock Nuts

SOME years ago I installed a high-speed engine to be used to operate a dynamo for lighting purposes. After I had the work completed, I turned it over to the assistant engineer, as I was very busy with other matters about the plant. Twice during the week he reported to me that the lock nuts on the crank end of the connecting rod had worked loose, causing a shutdown both times in order to find the liners which dropped out.

When Sunday came, I found time to look the matter over and see if I could locate the trouble, or cause.

This engine was of the self contained, enclosed type; the crank pin bearing was of the marine end type which consists of 2 babbitt lined parts bolted together with liners between them. I found the nuts



ARRANGEMENT OF NUTS WHICH GAVE TROUBLE AND THE REMEDY

on the bolts arranged as shown at A, which was the cause of their working loose. I arranged the nuts as shown at B, and had no further trouble from this cause.

When bolts are subjected to constant vibration, as are the nuts on the bolts which hold the 2 parts of a crank pin bearing together, there is a tendency for the nuts to work loose. To prevent this the second nut or lock nut is employed. When both nuts are of the same thickness it makes no difference which nut is screwed onto the bolt first, but when the check or lock nuts are less in thickness it does make a difference for this reason; when the first nut is screwed down to a bearing the upper surfaces of its threads are in contact with the under surfaces of the bolt threads.

When the lock nut is screwed down to a bearing on the first nut it forces it down so that the under surfaces of its threads come in contact with the upper surface of the bolt thread. Thus, the lock nut has to bear the entire strain, and when the nuts are of unequal thickness the thick nut must be located on the outside, as shown at B.

It is remarkable, at times, to note the simple mistakes like these that are made when the engine is being assembled in the shop. I came across another case similar to the one I have described, but the nuts were changed before the engine was started and no trouble was experienced from this cause. In 2 instances I have found this same mistake made with machinery other than steam engines.

Some 2 yr. later I installed a 50-kw. generator, direct connected to a high-speed horizontal engine which when started ran beautifully for about 2 days, when the engine began to pound badly at the crosshead bearing. Upon removing the pin and the 2 halves of the bearing we found that no space had been left for taking up lost motion, but instead the halves of the bearing had been allowed to come close together with a very nice fit for the cross-head pin.

I mention this, here, with the case shown in Fig. 1, in order to illustrate that it is not always the operating engineer who makes simple mistakes. W. S.

Extinguishing a Flaming Gas Well

THE method given on page 1059 for extinguishing a flaming gas well calls to my mind a similar case that I have seen. A gas well was being drilled to get gas for use in the Town Hall, and at a depth of about 800 ft., a flow of gas was struck at such high pressure that it forced the tools nearly out of the well. When the tools were taken out, the volume of gas was so great that it ignited from the fire in the boiler, and with a loud explosion the flames shot into the air 50 ft. Every means known to the drillers was taken to extinguish the flames, but the pressure was so great that nothing could be done.

After burning 2 days, an expert was sent for to extinguish the flame, and cap the well. When he arrived he had the derrick, which had been pulled away from the well to prevent burning it, pushed up as close as possible, and used it to hoist up a length of 8-in. casing to a nearly vertical position. Then the end was pulled over the top of the well with a rope. The pressure was so great that it took several attempts to get it over the well, and hold it there long enough to get the flames to pass up the pipe. When this was finally accomplished, the flames shot from the top of the casing. Then the end of the casing was jerked away from the well and the flames were put out.

The well was capped and showed a gage pressure of 95 lb. per square in., and, after the well was used for 6 yr., it still showed a pressure of from 30 to 40 lb., and at the end of 11 yr. use showed a pressure of 15 to 20 lb. per sq. in. J. C. Hawkins.

TOTAL PRODUCTION of petroleum for the world in 1911 amounted to 345,000,000 barrels, of which the United States produced more than 63 per cent.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Pulling Ice Cans

WILL you kindly advise me which you consider the best plan for us to follow in pulling the ice out of our ice-tank? I am enclosing 2 drawings of our tank for reference (Figs. 1 and 2). Our plant consists of a 12 by 30-in. compressor in tandem with an 18 by 30-in. Corliss engine and rated at 55 tons capacity, which would give us an ice making capacity of 25 tons at about 65 r.p.m.

Our tank contains 400 300-lb. standard cans and when running full time we aim to pull 84 cans every 12 hr. We use a 2-can air lift and have been in the habit of lifting 2 cans at 15 minute intervals the first hour and 2 cans every 20 minutes the second hour so as to make an average pulling time of about 8½ minutes a can; or, in other words, we pull 6 300-lb. blocks of ice the first hour and 8 300-lb. blocks the second hour.

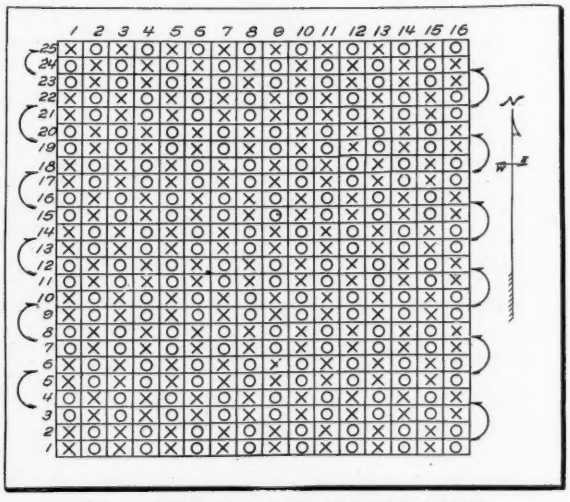


FIG. 1. PRESENT SYSTEM OF PULLING CANS

Starting the pulling in our tank at the southwest corner, XX, Fig. 1, we pull each 2 cans marked XX and leave each 2 marked OO and when we reach the end of tank we turn back on cans 15 and 16, No. 3 rows, continuing the process until we get to the last row which makes a single row to pull. Then we pull every other row on the same time. When we are entirely over the tank once we start on the cans marked OO, numbered 3 and 5, in the southwest corner of the tank on cans and continue the operation on the same time as before.

What I would like to know is whether it would reduce my capacity any by taking the first row and pull every can in it every 8½ minutes or according to Fig. 2 I would aim to lift just one can at a time instead of 2. I would be pleased to have your opinion on which you consider the best plan. A. E. O.

A. We would advise you to pull every can on every other row, as by this method your tank man cannot get confused in his pulling, and we prefer to number rows as they are pulled as marked out in Fig. 2. Start at the southwest corner of the tank and always pull

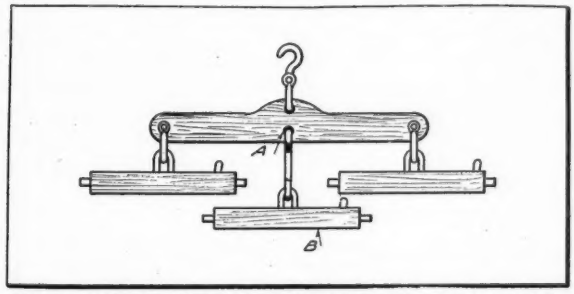


FIG. 3. DOUBLE CAN DOG PROVIDED WITH EXTRA SINGLE CAN DOG B.

rows 1, 2, 3, 4, etc. the first time across the tank; the second time pull rows numbered 9, 10, 11, etc., But as your tank contains 25 cans to the row, and you pull 2 cans at the same time, this will leave you one can at the end of each row to be pulled alone. This you can do by having an extra can dog, and attaching to your hoist as shown in Fig. 3. Drill a hole at A for the extra can dog to be used only when pulling a single can, and by using a hook as shown it is easily put on and taken off.

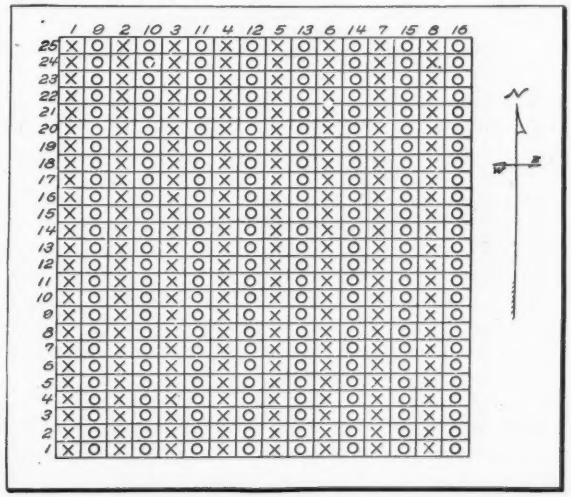


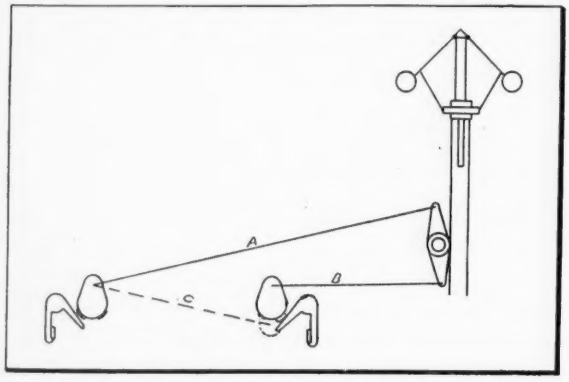
FIG. 2. PROPOSED SYSTEM OF PULLING CANS

If you have a good circulation, the manner of pulling ice will not affect the capacity of your tank. And with the 12 by 30-in. compressor running at 65 r.p.m., you should have no trouble in producing at least 29 to 30 tons of ice on tank containing 400 300-lb. cans.

Question and Answer Discussion

IN the issue of September 1, 1912, there appears that old question: "Explain the cause of water hammer" and Mr. Swingle has stated different causes, but why the "hammer" occurs when steam and water meet is not answered. Should like to know just what causes this noise when these 2 masses come in contact. I have seen different theories, but have wondered if the actual occurrances are known.

In question 2, under the same heading, Mr. Swingle states, that to make one governor rod longer and the other shorter, would disarrange the cutoff. In this I believe he is in error as my sketch will show. If rod A is lengthened and rod B shortened the knockoff cams will both be moved for a longer cutoff and vice versa. The effect will be to change the plane in which the governor balls travel; they will rise or drop to bring the cutoff back where it was before the rods were changed. This, of course, will change the governor adjustment and might set the balls in such a running plane that the safety cams would not engage the hook when the governor was at either one extreme or the other.



GOVERNOR DIAGRAM

If, as in some governor attachments, the rod A is omitted and a rod used as shown at C, there is then but one governor rod that being at B, while C is simply a continuation of B, attached as shown, so as to have an opposite direction of travel. Lengthening either of these 2 rods, C or B, and shortening the other would disarrange the cutoff.

Question 4 is answered correctly regarding the action of the pump, but long before a leak would occur large enough to be noticeable in the discharge of the exhaust it would be noticeable by a cracking sound in the heater occasioned by the mingling of the cold water and the steam used for heating. Again there is, or should be, a trap on all closed heaters to take away the condensed steam, and the leak if small would be discharged through this trap and the temperature change in discharge of trap would be perceptible to the hand.

There are many closed heaters from which there is no discharge for the exhaust except through the trap, as in a heater that is tied in multiple with a heating system, the steam being tied in at the top, the trap at the bottom relieving the condensation.

C. H. Reynolds.

Mr. Swingle's Reply

IN Mr. Reynolds' criticism of our explanation of the cause of water hammer in steam pipes, he says that we have not explained, "why the hammer occurs when steam and water meet." In reply thereto we need but refer to the latter portion of our answer to the original question, as it appears in the September 1 issue.

If Mr. Reynolds will carefully read that paragraph he will see that there is no reference to the "coming together of steam and water;" which are already in contact in the pipe through the process of condensation as previously explained, the water, of course, seeking the lower portions of the pipe, but still in contact with the steam. This condition will continue, and there will be a gradual increase in the quantity of water contained in the pipe, so long as there is no movement of steam in the pipe, or if the pipe is not provided with a system of traps that will carry away the water of condensation; but as stated in our answer, let there be a sudden opening of the engine throttle, even a quarter, or half turn of the hand wheel, the steam will at once start moving toward the opening, and it will carry the water along with it, or push it ahead if there be a large quantity of water, and the velocity of the mass will depend upon the area of the opening or outlet; the larger this is the greater will be the velocity, and the pound or hammer will occur when the water meets with any obstruction tending to interfere with or turn it from a straight course. This obstruction may be an elbow, or as is often the case it may be the throttle valve, or a cylinder head. The fact is, it is not the impact of steam against water, or of water against steam that causes the hammer, but it is the impact of water against the first metallic surface it meets with that tends to obstruct its passage, or to change its course too abruptly.

If you make one governor rod longer, and the other shorter what effect will it have on the cutoff?

This question does not specify which rod is to be made longer, and which one is to be made shorter. In Mr. Reynolds' description of the diagram of Corliss governor and cutoff mechanism which he presents, he explains at length what would be the effect of increasing the length of rod A, and of decreasing the length of rod B, which change he says would cause a longer cut off, and in this he is correct. Cutoff would occur later on both ends, so late in fact that the speed of the engine would be increased above normal; assuming of course, that load and boiler pressure remain the same as they were before the change was made.

This evidently would be a disarrangement of the cutoff, which had previously been correctly adjusted for a certain rate of speed under a given boiler pressure. But Mr. Reynolds neglects to explain what would be the effect on the cutoff shown in his diagram if rod A was shortened, and rod B was lengthened. This is another phase of the problem, and a glance at the diagram will show that the cutoff will be disarranged in another way; it would occur earlier in the stroke at one end, than it would at the other.

The fact is, that when once the cutoff is correctly adjusted, and the engine is running at the proper speed, any changes whatever in the lengths of the governor rods, or any other parts of the automatic cutoff mechanism will serve to disarrange the cutoff, and interfere with the proper working of the engine.

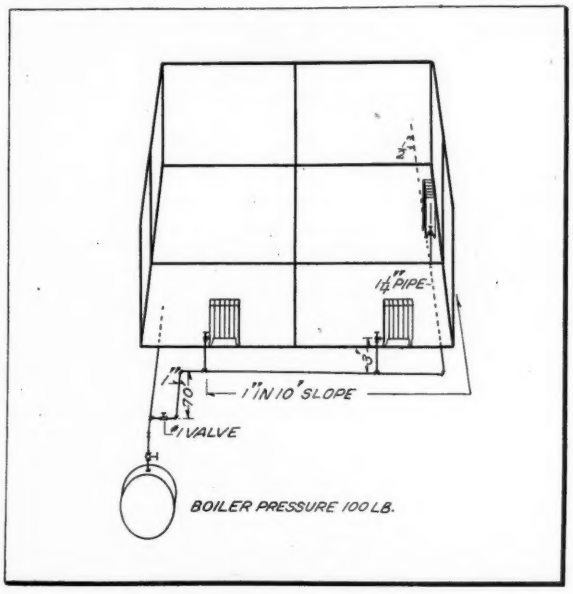
C. F. Swingle.

(There may be noise, which is sometimes called water hammer when steam meets water and is condensed quickly, as when steam is run into a barrel of water. This is due to the inrush of more steam to fill the space and the consequent rapid expansion, the same as in the exhaust of an engine or a clap of thunder. Such action does no real damage, except the annoyance, unless the water is driven forward by the steam against a solid obstruction as explained by Mr. Swingle.—Editor.)

Heating a Residence

WILL you please inform me if the system shown in the accompanying sketch will answer for heating the ground floor of a small residence? I do not want to go to the expense of a reducing valve, so I thought to regulate the steam by the valve at the boiler marked No. 1. This pipe will raise 3 ft. from the ground to the radiators.

Will the steam force the water of condensation up and through the radiators without causing water hammer? About what pressure will a cast-iron radiator carry safely? Will 14 ft. heating surface be sufficient to heat a room 10 by 12 ft. in a frame building with lowest temperature about 0 deg. F.?



PROPOSED SYSTEM OF HEATING

S. S. S.

A. The arrangement of piping that you have shown for heating your house would not be satisfactory or safe. You have shown the radiators connected one after the other on the line. That would mean that if you shut off the radiator nearest the boiler, it would cut off all steam from the other radiators. Further, if you shut off the second radiator or the third, it would mean that full boiler pressure would accumulate in the radiator between there and the boiler, and no radiator is built which will stand 100 lb. pressure. The proper connections would be as shown herewith.

Since you do not wish to go to the expense of a reducing valve, you must leave the outlet to your steam pipe, which supplies the house, always open; so that pressure cannot accumulate in this pipe, even though all the radiators might be shut off. I should be in favor of putting a steam gage on the house supply main beyond the valve, so that you could always tell what pressure you were carrying on that line.

In regard to the heating surface, I do not believe 14 sq. ft. will be sufficient. Using steam at a pound or 2 above atmosphere, you should have at least 20 sq. ft., and it would be better to put in 24. The 1-in. supply pipe will be all right to carry the steam to the radiators, but I would rather have 1¼ in. beyond the first radiator connection, to make sure of having plenty of area for the condensation to pass on. The pipe should be sloped downward at least 1 in. to every 10 ft. to the outlet end.

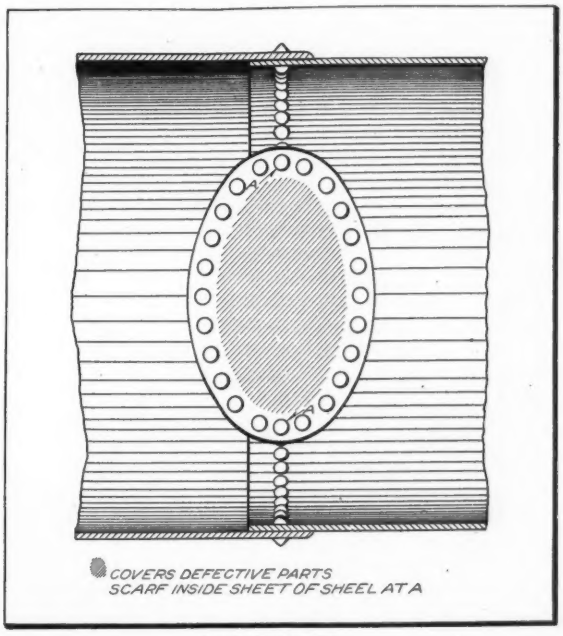
A. L. R.

Patching a Bagged Boiler

HOW would you put a patch on a boiler that was badly bagged, if the girth seam passed through the bag?

A. Herewith is a rough sketch of a patch showing a temporary relief for trouble such as is outlined. The sketch, however, lacks the necessary details for the installation of a patch as required by law; however, it doubtless will serve to give a general idea for the benefit of your readers.

You will note that the patch is placed on the inside of the sheet, the defective part having been removed,



BOILER PATCH

and while we have placed several patches of the kind outlined, we do not consider it a practical method, inasmuch at each end of the patch it is necessary that there be 3 thicknesses of metal.

A proper and more satisfactory way would be to remove the lower front half sheet and cut out a lower section of the second sheet and install a new front sheet extending well into the second sheet, thereby bringing further away from the fire the bottom section of the girth seam. We install many sheets of this character with the best of results.

The Graves & Marshall Co.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Turbine Problem

CAN any of the readers of Practical Engineer, explain the theory of the draft tube?

We have a turbine that is supposed to develop 67 hp. with a head of 60 ft. and a flow of 791.5 lb. of water per second. The penstock is 42 ft. and the draft tube 18 ft. in length. We can only get 11 in. of vacuum, and develop 50 hp.; shouldn't the 18 ft. draft tube be equal to 16 ft. head if the tube is tight and properly constructed? Can any reader explain the reason why we cannot get the full horsepower?

H. P.

About Tube Cleaners

I SHOULD like to hear some of the readers opinions of turbine tube cleaners for return tubular boilers. Some engineers contend that these cleaners damage the tubes. M. V.

Hot Pond Problems

ANSWERING J. F. D.'s question about a hot pond, in Oct. 1 issue, there is nothing gained by running the pipe under water. I have a pipe that enters a pond from a 45-deg. ell; the end of the pipe is about 15 in. under the water. Your back pressure will not be over 2 lb. Put a ½-in. hole in the top of 45-deg. ell for a

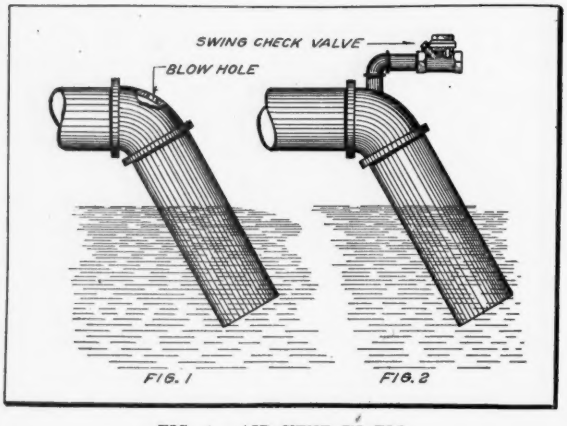


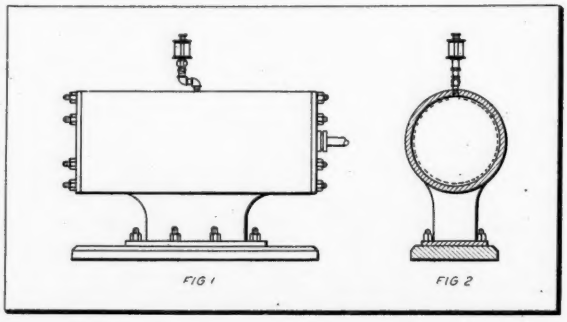
FIG. 1. AIR VENT IN ELL
FIG. 2. LOCATION OF CHECK VALVE

vacuum breaker to prevent water hammer, as shown in Fig. 1. If the steam from the blow-hole is objectionable connect a 1-in. swing check valve on the vent. Air can enter the pipe through swing valve and you will have no trouble.

I keep a pond open all the year with a 7-in. exhaust from saw mill; the pond is 15,000 sq. ft. in area and the boilers 900 hp. W. W. Warner.

Lubricant for Air Compressor

REPLYING to Eugene Hibert, page 951, Sept. 15 issue of Practical Engineer, I wish that he had stated about how much glycerine he uses an hour, also as to his method of feeding it. His letter, to my mind, indicates that he is feeding too much, but if feeding too little glycerine with a weekly washing out the cylinders with soapy water is not feasible, and will not meet the demands, I would advise that the method of feeding the glycerine be altered; the method of feeding lubricant to a steam engine cylinder will not give satisfaction with the air compressor, because the air must not be charged with the lubricant.



Lubricators should be of the sight feed type, so that the attendant can know at all times just how much lubricant is being fed and the lubricators should be so arranged that the lubricant will not leave the cylinder walls, because of its tendency to crawl, which, aided by the moving piston, will distribute the lubricant over the surfaces where it is needed. This could be accomplished by the arrangement shown in the sketch, and with a few days' close attention the attendant will know as to just how much lubricant to feed.

Thos. C. Robinson.

Correspondence Education

RELATIVE to the enquiry by Oliver W. House, page 1056, Oct. 15 issue of Practical Engineer, should like to say that I believe one can learn engineering by correspondence and also that it would be a great help to many practicing engineers who have graduated from college. No money gives greater returns than that invested for the improvement of the mind, and keeping it polished. If one doesn't continue to study he will surely retrograde.

To learn engineering by correspondence requires greater application on the part of the student than would be required at a college or university, because he must depend on his energy. T. C. Robinson.

A MESSAGE FROM OPERATING REFRIGERATING ENGINEERS

To Managers and Owners of Ice and Refrigerating Plants

THE development of the ice-making and refrigerating industry, especially in the southern part of the United States, forms a story of remarkable progress and achievement, under difficulties, and the possibilities of the future are limitless.

From an insignificant start, with a small number of poorly equipped and inefficient plants, a few short years ago, the rise of the industry has been steady and rapid, until it today ranks with the important industries of the nation and seems destined to outstrip many of them. A large number of important industries are dependent for their very existence upon the refrigerating machine, and no home is complete today without the refrigerator.

In keeping with this progress and to better equip themselves for the responsibilities of the future, the refrigerating engineers held a convention three years ago and organized an association known as The Practical Refrigerating Engineers' Association. Two annual meetings have already been held and the third has been called for December 5, 6, and 7, in Atlanta.

The motto of this association is: "Economy, Morality and Competency" and its object is the education and moral advancement of the operating refrigerating engineer. This laudable purpose is more clearly explained in the Foreword of the revised Constitution and By-laws adopted at the last convention, which reads as follows:

The chief object of this association shall be to further the education and elevation of its members in the art and science of refrigerating engineering.

The principal means toward this end shall be the holding of meetings and the reading and discussion of appropriate papers, and for social intercourse.

Each member subscribes to the belief of identity of interest of employer and employee, and this association shall at no time be used for the furtherance of strikes or anything that will in any way interfere with perfect harmony between them.

This association shall at no time take partisan issue with rival interests in the ice and refrigerating business, neither shall it be used for political or religious purposes.

Its meetings shall be devoted to the business of the association, and at all times preference shall be given to topics tending to the education and instruction of its members.

It will be noted that the association recognizes the important fact that the interest of the employer and employee in the refrigerating field are identical—that which is helpful to the refrigerating engineer must be beneficial to the plant where he is employed, and that practical knowledge, which can only be gained through close association and co-operation, is essential to the success of every plant, large or small.

The most substantial co-operation that can be offered by the manufacturer is his support; first, as an associate member, and second, his assistance in gaining admission to the association for his engineer. Come to the Atlanta convention and bring your engineer; if this is impracticable see that your engineer is on hand and makes application for membership. You will thereby assist a laudable cause and at the same time promote your interest. F. H. Ladd, President,

Practical Refrigerating Engineers' Association.

ENGINEERS OF YESTERDAY

By the Journeyman Engineer

"YES, times have changed and there are one or two 'how's and why's' I'd like to have your readers know about and think over because I believe it will do some of them good.

"When I started 53 yr. ago, to my knowledge there wasn't a single paper published exclusively for the engineer or fireman. The nearest containing information for our trade was the ———— and they asked $5.00 a year for a subscription.

"And what a man could get from that magazine and put to practical use was precious little. Engineers of our day took the full course of bumps and knocks to get education, and believe us we paid dearly for our inexperience; that is, most of us did. The others are 'up yonder' or following some other line altogether. Now, back to my point—today there are at least 3 good engineers' magazines at a price within reach of all.

"I know most about Practical Engineer and talk from knowledge of your paper. I wish I had saved the magazine of 50 yr. ago to compare it with what you are publishing today. Do your readers appreciate what they are getting now for only $1? No, I venture to say not one in 5 appreciates it justly, because the average man thinks not of what he has now to make use of and grow valuable on; but what he hasn't got or wishes he had.

"I know your paper is gaining engineer friends tremendously fast and all that—but if more of them could see the value of a paper like yours as I do you'd have to build a fence to keep them away."

G. O. F., Louisville, Ky.

"I'm glad you dropped in—have a chair. Did the boys at the works tell you you would find me here?

"Chatting has always been my weak point, so I expect you've come here to play me through my weakness. Fire ahead, what's on your mind? Want to know why I have kept on reading your paper since retiring? Well, that's easy.

"In the first place I used to have what some people call a bad failing—asking questions. I've had it ever since a boy.

"As I grew older I turned this failing into a hobby. How? Again that's easy. Instead of asking an unintelligent question, I have tried to think the answer out myself first and then when satisfied my answer was reasonable, ask someone else's opinion on the same subject, thereby having the benefit of my own conclusion and the other man's, too. 'What's this to do with Practical Engineer?' Well, I'll tell you. I've said this was a hobby—what more natural thing for me to do than set this hobby to work in Practical Engineer? How? Through 'Questions and Answers' Department. Not alone have I asked Practical Engineer to answer questions on subjects with which I was not familiar, but I have tried myself to answer questions asked by other engineers in that column. In this way I have kept up on many things which otherwise I would know nothing about. Mind you, I am now a little too old to use this knowledge, but I practiced this very thing all through my active life. It is my firm conviction that if more of your readers would ride some sort of hobby in connection with the information that is given them in their engineering papers, much greater advancement would be made by every one of them."

PRACTICAL ENGINEER

Trade-mark reg. U. S. Pat. Office.

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH

At 537 So. Dearborn Street, Chicago, Ill., by the

TECHNICAL PUBLISHING CO.

New York, 150 Nassau St. Cleveland, Am. Trust Bldg.

Subscription Price One Dollar a year in advance to any Post Office in the United States or Mexico or United States possessions.

To Canada One Dollar and Seventy-five Cents; to Other Countries Two Dollars and Fifty Cents a year. Single copies 10 cents.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago, Ill. Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

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Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Circulation of this issue, 23,500

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DEMANDS FOR HIGHER VELOCITIES

Not many years ago a speed of 100 r.p.m. was considered a maximum for large steam engines but the demand for space and compact direct connected electrical generating units has stimulated the investigation of factors affected by increase of speed to such an extent that with modifications in details of design we now have reciprocating steam engines running as high as 300 r.p.m., giving no more trouble than those running at lower speeds with little difference in economy of operation and considerable reduction in cost.

The same demand of power plant owners has brought about the perfection of steam turbines in both large and small units. Similar demands are apparently forcing another change in power plant practice in line with the increased speed of engines. This is the steam piping system. While formerly it was general custom to design piping for velocities of 4000 to 4500 ft. a minute, as stated by Mr. Fischer on another page of this issue, we have, in many plants where large turbines are installed, velocities as high as 21,000. The principal reason for this increased velocity is the reduction in cost of piping and installaton. Under operating conditions and piping designs as they existed a few years ago, present high steam velocities would be impossible or decidedly impractical and dangerous.

For instance, the past few years have witnessed improvements in boilers and methods of treating feed waters which have decreased the liability of foaming to a minimum; improvements in furnaces and stokers have made possible more even firing and less danger of priming from water containing foreign matter; regulation of feed water supply and water level is, by present day apparatus, made an easy matter and by all these the danger of water hammer and drawing water over to the engine is reduced. Again, the design of piping in long radius bends has cut down friction, improved methods of insulation have reduced condensation, and steam separators and drips have been perfected to such an extent that, when properly installed and drained, practically no water gets into the system.

Lord Kelvin's rule is that the most economical section of an electrical conductor is that for which the annual interest on capital outlay is equal to the annual cost of energy wasted, and it would seem reasonable to suppose that, friction alone being taken into account, a similar rule might apply equally well to economy in steam transmission.

This move towards higher steam velocities is indicative of progress in the perfection of power house equipment, but the extent to which it may be economically and safely carried is a question as yet unsolved which should receive the careful thought of those installing new piping systems.

THE ANNUAL MEETING of the Practical Refrigerating Engineers' Association will be held in Atlanta, Ga., December 5 to 7. Members of the Local Entertainment Committee are: H. J. Botchford, S. C. Johnson and J. A. Rasbury. A most interesting program of professional sessions and entertainment is being prepared, and it will pay everybody who can get there, to attend.

STATEMENT OF OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

of Practical Engineer, published Semi-Monthly at Chicago, Ill., required by the Act of August 24, 1912.

Note.—This statement is to be made in duplicate, both copies to be delivered by the publisher to the postmaster, who will send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office.

Name of— Post-Office Address—
Editor, Arthur L. Rice, 537 S. Dearborn St.
Managing Editor, Arthur L. Rice, 537 S. Dearborn St.
Business Manager, E. R. Shaw, 537 S. Dearborn St.
Publisher, Technical Publishing Co., 537 S. Dearborn St.

Owners: (If corporation, give names and addresses of stockholders holding 1 per cent or more of total amount of stock.)

E. R. Shaw, 537 S. Dearborn St.
A. L. Rice, 537 S. Dearborn St.
C. S. Clarke, 537 S. Dearborn St.
C. B. Leech, 1246 Bonnie View Ave., Lakewood, Cleveland, Ohio.

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Average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date of this statement. (This information is required from daily newspapers only.)

Chas. Sanford Clarke.

Sworn to and subscribed before me this 3rd day of Oct., 1912. Warren A. Lathrop,
Notary Public.

[Seal.] (My commission expires October, 1914.)

NEWS NOTES

WHAT PROMISES to be an investigation of more than usual interest and utility is being conducted by the State Engineering Experiment Station at The Pennsylvania State College, under the direction of Professor J. A. Moyer of the Mechanical Engineering Department. With the increase in the price of gasoline has come the demand for some cheaper fuel that will give as good results. Kerosene would meet the demands if a satisfactory carburetor can be designed, and it is with a view of determining the merits and defects of various types of carburetors that the investigation is being carried on. The price of gasoline has nearly doubled in this country in the past year, while in England the price has risen to 50 cents a gallon for "motor spirit."

Many of the writers in the trade journals in England advocate the use of a mixture of gasoline and kerosene, but point out that without an efficient carburetor no such mixture may be used. Professor Moyer, who has made numerous experiments on smoke washing, and electrostatic treatment of smoke, has already installed at the college a motor built to utilize the energy from either of the 2 fuels mentioned and suitable for use on farms and country estates. Experiments will also be made on various mixtures, and a carburetor valve will be designed to shift the fuel supply automatically from a small gasoline tank, used only for starting, to the main kerosene tank.

These experiments should be of interest to manufacturers and users of gasoline motors throughout the country.

AT THE REGULAR monthly meeting of the Board of Directors of the Joseph Dixon Crucible Co., held Monday, October 21st, the following changes in the officers and board of directors were made on account of the death of Vice President William H. Corbin. George E. Long, former treasurer, was elected vice president to succeed Mr. Corbin; J. H. Schermerhorn, former assistant secretary and assistant treasurer was elected to membership in the board of directors and treasurer of the company. Albert Norris was elected to the office of assistant secretary and assistant treasurer.

W. E. SANDERS, formerly Sales Manager of the American Rubber Co., of Cleveland, O., and later with the Home Rubber Co., of Trenton, N. J., has accepted a position as Sales Engineer for the C. J. Tagliabue Mfg. Co., of Brooklyn, N. J.

THE 26TH MEETING of the Ohio Society of Mechanical, Electrical and Steam Engineers will be held at Hotel Portage, Akron, O., November 21 to 23. Besides inspection trips to the various large plants of interest in and about Akron, there will be attractive entertainment features and papers will be presented on "A System of Gas Engine Governing," by Geo. S. Cooper, of the Buckeye Engine Co., Salem, O.; on "The Lentz System Applied to Steam Engines," by Siegfried Rosenzweig, of the Erie City Iron Works, Erie, Pa., and on "The Manufacture of Tin Plate," by E. W. Patton, of Follansbee Bros. Co., Follansbee, W. Va.

AN IMPORTANT RECENT DEVELOPMENT in the transportation facilities of the middle west is the completion of the freight yards of the Chicago and Northwestern Railroad at Proviso, about 13 miles west of Chicago. Here in a yard 2 miles long is installed a present capacity of 6000 freight cars, which by spring will be increased to 10,000. There is also a round house with stalls for 58 locomotives, and elaborate accommodations for the comfort of employes. By this provision and a new line of track running up the Des Plaines Valley from Proviso to Lake Bluff and intercepting the lines of the Wisconsin and Milwaukee divisions, all transfer of freight from eastern or northern lines to the western branch, or vice versa, will be made at the Proviso yards without entering the city, leaving the city yards free for passenger traffic and local freight. Connection is made at Proviso with the Indiana Harbor Belt Railroad, which passes around the city as far as Indiana Harbor and Gary, thus connecting with all the southwestern, southern and eastern lines, permitting the exchange of freight between all divisions of the Northwestern Railroad and any other line entering Chicago.

The yard is the largest in the country except that at West Pittsburgh. It covers some 250 acres and has been completed at a cost of something over a million dollars. One feature of the new plant is the sinking of driven wells to a depth of 1800 ft., thus drawing water from a sandstone rock, which is suitable for locomotive use without treatment to remove scale-forming impurities.

RIEHLE BROS. TESTING MACHINE CO. reports that it has just finished building the largest screw power testing machine in the world, viz., 1,000,000 lb. on 2 screws, which they are shipping to the American Steel Foundries, Alliance, Ohio.

ON OCTOBER 29 a fatal boiler explosion occurred in the basement of the Salem Bank and Trust Co., Salem, Ore., W. G. East, Cashier of the Bank, being injured so that he died the following day, and L. B. Muchmore and Harry Ahlers being seriously injured. The boiler was an old one, bought a few months before after removal from a former heating plant, but no definite information is available as to the exact cause of the explosion. Apparently there was no inspection of the boiler at the time that it was installed.—Chas. Burns, Springfield, Ore.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

A NEW STEAM TURBINE

Required Conditions for Good Economy and Service Met by a Velocity Stage Design

IN general, 5 main variables enter into the design of a turbine, 2, or in some cases 3, of which, are fixed by the circumstances, and the remainder of which must be made to conform. The 2 which are usually inflexible are the capacity and the energy range; that is, the steam pressure and superheat at admission, and the vacuum or pressure at exhaust.

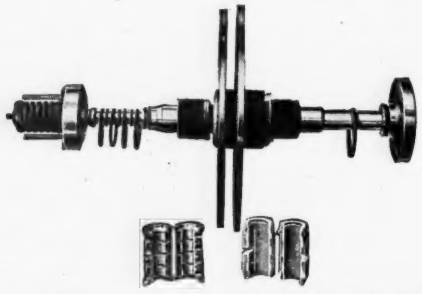

FIG. 1. SHAFT, WHEELS, AND GOVERNOR ASSEMBLED

The remaining variables are the rotative speed, the number of stages and the wheel diameter. In many cases, the rotative speed must be the speed at which the driven machine must be run, although, in general, it is possible to design a more efficient and satisfactory

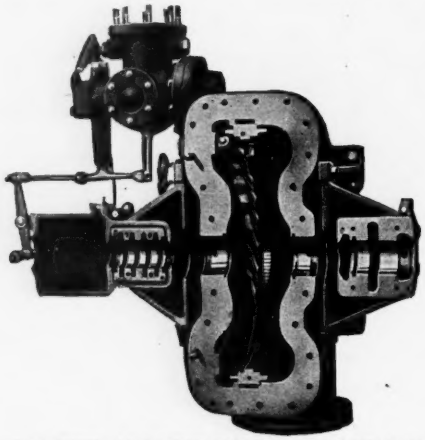

FIG. 2. TOP VIEW OF LOWER HALF OF DE LAVAL CLASS C TURBINE CASE

turbine, if this variable is not predetermined, as where gears are used for connecting the turbine to the driven machine.

If the rotative speed is fixed, the wheel diameter and number of stages will depend one upon the other. The number of stages, together with the pressure range, determine the amount of energy converted per pound of steam per stage and therefore the spouting velocity of the steam. For good efficiency, the bucket velocity should bear a fixed ratio to the spouting velocity.

Considerations of strength limit bucket diameter for a given wheel diameter and speed; logically, therefore, the length of buckets and the diameter of the wheel should be determined first, together with the number of revolutions; this will give a turbine with the least number of stages and in general, greatest simplicity and highest efficiency. While the final steam velocity and the area of the buckets of the last wheels must provide for the passage of sufficient steam to generate the power required, the use of a larger wheel than is necessary for this purpose, is undesirable, since

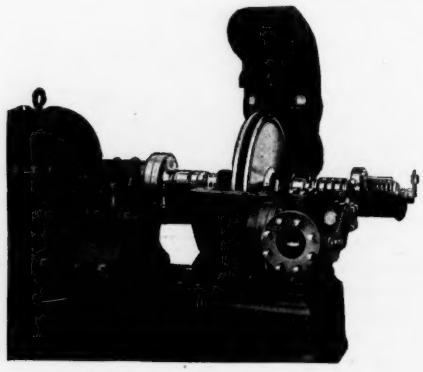

FIG. 3. VELOCITY STAGE TURBINE WITH COVER LIFTED TO GIVE INSPECTION OF PARTS

the loss of energy by disk friction increases as the square of the disk diameter and as the density of the steam.

Bearing in mind the preceding statements, it will be realized that different types of turbines suit themselves best to different conditions of service.

Types for Various Service

IN impulse turbines, the buckets move at approximately half the velocity of the spouting steam, while in velocity stage turbines, the best bucket velocity is approximately the velocity of the steam divided by twice the number of moving buckets in each pressure stage. In other words, both of these types of turbines, and especially the latter, are suitable for small units, the impulse turbine being better in the larger sizes. In the multi-stage simple impulse turbine, the steam leaving the nozzles strikes only the moving buckets and at a relative velocity equal to one-half the spouting velocity. The efficiency of the bucket is not therefore paramount.

In the case of turbines which are to operate on a reduced range of pressure, as back-pressure turbines, or low-pressure turbines, velocity staging shows relatively better efficiences. Multi-staging by velocity stages appears to be in many respects the most feasible system for small-power turbines.

Practical Considerations

THE chief requirements for small turbines are safety, hardiness, and, in many circumstances, steam economy. Safety depends primarily upon the reliability of governing devices and upon the strength of parts, as determined by design and materials used, and upon measures taken to prevent destruction of the machine and its surroundings in case runaway should occur. Hardiness, or the ability to run for long periods without attention or repair, should have combined with it accessibility and cheapness of maintenance.

Steam economy is partly determined by the type of turbine and the steam and speed conditions under which it must operate, but also by good design and construction and the possibility of easily and quickly renewing parts subject to wear or deterioration. Among such details are wheel buckets separable from the wheel rim and so attached that renewal is not difficult; nozzles replaceable, in case it should be desired to adapt the turbine to changed steam conditions; guide vanes separable from the diaphragms between stages or other supports, since they are subject to wear from wet steam and it may be necessary to replace them in order to bring the turbine back to its primal efficiency. Bearings, of course, should be interchangeable and easy to renew. It should further be possible to get at working parts without disconnecting steam or exhaust piping.

Governing

PRACTICAL application of these points is shown in the accompanying cuts of a new line of velocity-staged turbines recently brought out by the DeLaval Steam Turbine Co., of Trenton, N. J. Figure 1 shows the shaft with wheels, governor, packings and couplings assembled thereon. The speed governor consists of 2 governor weights pivoted on knife edges and compressing a helical spring arranged with the axis concentric with the axis of the shaft. Compression of the spring is accompanied by the forcing out of a pin which, as may be seen from Fig. 2, through a system of levers, raises and lowers the double-seated poppet valve in the governor valve casing. The tension of the spring may be adjusted to give the speed regulation desired. The governor is completely enclosed in a stationary casing, presenting no external moving parts.

By means of this relatively simple governing device, close regulation is secured, but to avoid accident due to possible contingency, a second speed-limiting device or "emergency" governor is also employed. This consists of a radial bolt set in the disk which forms the base of the speed governor and is held in by a strong spiral spring. When a certain speed is exceeded this bolt will project and strike a small lever, Figs. 2 and 3, tripping a mechanism which thereupon closes the butterfly valve in the steam inlet opening, see Fig. 3. This emergency governor is entirely independent of the speed governor and comes into action whenever a certain speed is exceeded, regardless of the action of the speed governor.

As an additional precaution in the present turbine, an enclosing armor is provided in the form of a steel ring in which the stationary guide buckets are held, Fig. 2; this ring effectually prevents the escape of fragments which might penetrate a cast-iron housing.

The housing itself consists of 2 parts, the cover, which may be raised readily, rendering the wheel, shaft and all interior parts at once accessible, and the lower part, containing the steam inlet and outlet openings. Adjoining parts are definitely located with respect to one another by taper dowels to insure correct and easy assembling. Economy of this turbine does not depend upon the maintenance of small running clearance.

To give hardiness or reliability, a first consideration is the securing of absolute freedom from vibration. This is accomplished primarily by careful balancing

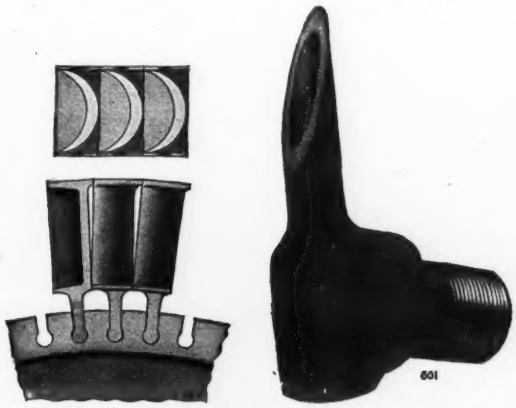

FIG. 4. BUCKETS AND METHOD OF MOUNTING
FIG. 5. INDIVIDUAL NOZZLE FOR COMPLETE EXPANSION OF STEAM

of rotating parts and by the use of a shaft so proportioned that its critical speed is far above the normal speed of operation. The shaft used in the present turbines, seen with the rotating parts mounted thereon in Fig. 1, is made of hammer-forged, open-hearth steel, ground and polished over its entire surface on a dead center grinder, thus insuring perfect alinement.

The shaft is carried in 2 bearings, one of which is a plain ring-oiled bearing, while the other is a ring-oiled thrust bearing of the marine type, intended to prevent endwise movement of the shaft and to hold the wheels in proper position relatively to the nozzles and to the stationary blades. The turbine is perfectly balanced for axial thrust, since all the wheels are surrounded by steam at uniform pressure.

Wheels are of the usual DeLaval construction, centered on the shaft by ground fits, the whole series being located on the shaft by a collar and held in place by a heavy lock nut. Each wheel, which carries but one row of buckets, is carefully balanced, as is also the series after assembling upon the shaft.

Besides the bearings, about the only parts of a steam turbine that are subject to wear, are the nozzles, buckets, and guide vanes. Prevention of wear is largely a matter of supplying dry steam only and of using suitable materials and having a suitable finish for the buckets and blades. Long experience with high velocity steam jets has convinced the builders of the De Laval turbine that the most satisfactory form of bucket to resist wear is a drop forging of suitable noncorrodible metal, upon which the original scale formed in the drop forging process has been allowed to remain.

Buckets of the present turbine are made of nickel bronze by this process and are inserted in the rim

of the wheel by bulb shanks fitted into slots milled and bored in the rim transversely to the plane of the wheel, Fig. 4, a mode of attachment which develops the full strength of the bucket and at the same time permits of removing or replacing individual buckets without disturbing others. The bucket tips have projections front and rear which touch adjacent buckets to form a continuous rim, which has proved to be beneficial in reducing the fan action of the blades and in guiding the steam jet.

The guide vanes are similar in form and are attached in a similar manner to the retaining ring already referred to. The latter is divided on the horizontal plane of the center line, the upper half being fastened to the wheel case cover, while the lower half rests in a groove from which it may be lifted upon the removal of the shaft and wheels.

All internal parts are at once accessible upon removing the casing cover and without disconnecting either the steam supply or exhaust piping. Upon removal of the bearing caps and unbolting the coupling, the rotating member may be taken out, which gives access to all parts of the turbine. Each and every

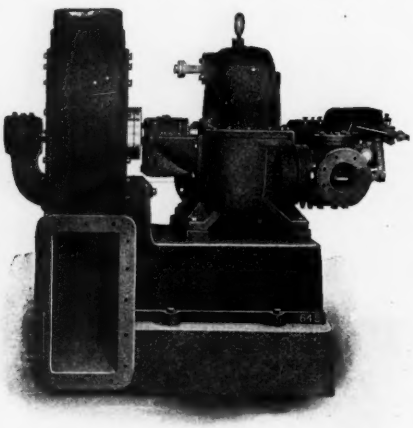

FIG. 6. CLASS C DE LAVAL TURBINE DRIVING CENTRIFUGAL BLOWER

part that will be worn by wet steam or from any other cause is perfectly interchangeable, so that it may be quickly and cheaply replaced.

Good steam economy is often desirable, even in small turbines. It is important that the proper ratio between bucket speed and the spouting velocity of the steam be maintained, that the loss by skin friction of the disk revolving in the steam and the fan action of the buckets be reduced to a minimum, that nozzles and buckets be of an efficient form and constructed of material favorable to the retention of this form and that the nozzles be operated at full pressure as much of the time as possible.

Throttling is the only method of governing that is practicable for turbines of small size, and, in fact, has been found to give the most satisfactory results in turbines of all sizes where arrangements are also made for turning on and off nozzles, as required to meet the demands for power. In one of the turbines containing 10 nozzles, 6 are fitted with hand-controlled valves and may be cut out of service when the demand for power is light.

The nozzles themselves, Fig. 5, consists of solid bronze castings in which the orifice through which the jet is delivered is carefully bored and reamed to the shape adapted to secure the desired ratio of expansion and the delivery of a jet free from turbulence and of which all elements are truly parallel. In the heel of the nozzle piece is a plugged hole through which access is had for machining the throat of the orifice.

These nozzles communicate with the steam chest cored out in the wall of the wheel case and are held by nuts and sealed with copper gaskets. They can be removed easily if it should ever be necessary to replace them, as in case it should be desired to operate the turbine under steam conditions different from those for which it was originally designed. Inasmuch as full expansion takes place in the nozzle, the only parts of the turbine coming in contact with steam at boiler temperature or pressure are the steam chest and the inlet ends of the nozzles, the wheel case proper being filled with steam at exhaust temperature and pressure. Thus the stuffing boxes are not subjected to pressure greater than that of the exhaust.

The only way in which high pressure could accumulate within the casing would be through the stoppage of the exhaust outlet. To guard against any accident from this cause, however, an adjustable bronze safety valve is fitted to the upper part of the casing cover. If the turbine is to be operated with superheated or high-pressure steam having a temperature of 450 deg. F., or over, the parts of the governor valve and safety stop valve coming in contact with the high-pressure steam are made of steel.

A NEW TUBE SCRAPER

WE illustrate herewith an improved type of flue scraper, made on the lines of the old-time Engineer's Favorite as to general form and adjustability, the improvement being in the scraping arms The old style malleable-iron arms would act as sort of a drag, but the form of arms now used, resembling a scoop, is claimed to remove soot or scale from the tubes more effectively.

Because of the form in which the scraping arms are made this claim would seem to be reasonable, as

FIREMAN'S FAVORITE TUBE SCRAPER

it is clear that soot or dirt can better be removed by a scoop motion than in any other manner. The arms are made of tempered steel, so are very durable, and can be easily replaced.

The manufacturer of this new tube cleaner, the A. W. Chesterton Co. of Boston, Mass., distinguishes it from the old style by calling it the Fireman's Favorite tube cleaner.

REORGANIZATION OF THE Platt Iron Works Co., of Dayton, O., is completed and the new company, which is a Maine corporation, is ready to serve its patrons with better facilities than ever before. It is free from floating indebtedness, has ample working capital and is installing improvements costing upwards of $50,000. The new officers are: President, J. B. Reichmann; vice president and treasurer, E. F. Platt; secretary, John Sturgess; second vice president, J. F. Hartlieb.

THE CLIPPER BELT LACER

Light Weight Lacer with Carded Hooks

THIS little tool was originally patented in England and brought to this country in 1907. The first tool made from the English designs was sold on Oct. 12 of that year. As originally made, it was used with a mallet and the hooks were placed in the tool one by one a very slow and unsatisfactory process.

Sept. 1, 1910, the first card of hooks was ready for the market. This very greatly simplified and quickened the operation. March 29, the No. 2 lacer came out. This was a climax to the whole transaction, for with the No. 2 lacer and carded hooks, anyone of ordinary intelligence can lace a belt more quickly, and do it much better than with any other device on the market today.

The hooks are carded on paper wide enough to fill the entire machine. If one desires to lace a belt narrower than the machine, a pair of scissors (furnished with each tool) is used to cut the paper card into the right width. This is then inserted into the machine and the pin put in, which holds it in place, the paper taken out and the machine is ready for operation.

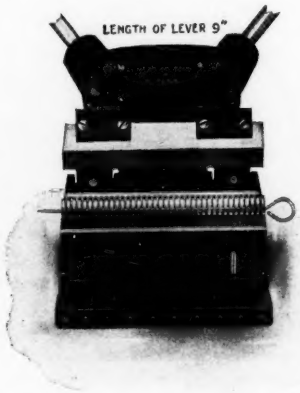

FIG. 1. CLIPPER BELT FASTENER NO. 2, FRONT VIEW

For ease in operation, the ratchet is hinged on the base of machine so it can be laid back out of the way, allowing the center and side heads, which hold the clinch bar, to be thrown back out of the way, giving free access to the lacer to insert the hooks. The lining bar which meshes into the lacer and engages the hooks, is handled by the plungers in the side heads, backed up by springs, so that when the side and center heads are brought forward, the plungers engage in the lining bar, thus keeping the hooks in alinement during the operation.

The center head is brought forward until clinching bar comes in contact with the hooks, then ratchet is brought forward into position and pawl engages it. Then belt (which is held in place by bracket shown on front of tool) is inserted between hooks, and levers are pressed down. As the levers are raised up, the pawl takes a step up the ratchet, and so on until the operation is completed and the hooks are pressed in flush with the surface of the belt, in all taking less than 2 minutes. The other end of belt is finished in the same way and the rawhide pin inserted to connect them.

Another particular advantage of the "Clipper" is its portability. Weighing about 19 lb., it is easily taken to the belt and operated in any position, thus saving a great deal of time and loss of output.

Over fast-running pulleys it has been exceedingly successful, for the joint, being finished flush with the surface of the belt, prevents any jump or vibration of the same, running over the pulley as smoothly as an endless belt. The joint, being very light and short, presents any chance of its slipping on the pulley.

From a very small beginning in 1907, the business has grown to a point where more than 12,000 lacers

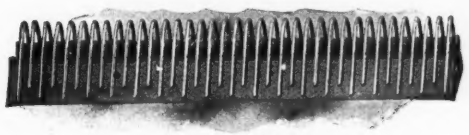

FIG. 2. CARD OF HOOKS

up to the present time, have been sold, which the manufacturers believe is sufficient evidence of the popularity and advantage of the product. The Clipper Belt Lacer Co., successor to J. B. Stone Co., Grand Rapids, Mich., manufactures the machines, which are handled by the leading engineering and mill supply houses throughout the country.

NOTICE OF EXAMINATIONS

THE UNITED STATES CIVIL SERVICE COMMISSION announces an open competitive examination for mechanical draftsman (male), immigration service. From the register of eligibles resulting from this examination certification will be made for temporary employment in the position of mechanical draftsman in the Immigration Service, Ellis Island, New York, and vacancies as they may occur requiring similar qualifications. Appointments will be made at from $5 to $6 per diem and will continue for a period of about 6 months.

This examination is open to all male citizens of the United States who meet the requirements. Persons who meet the requirements and desire this examination should at once apply for Form 1312 to the United States Civil Service Commission, Washington, D. C. No application will be accepted unless properly executed, including the medical certificate, and filed with the Commission at Washington prior to the hour of closing business on November 25, 1912.

THE UNITED STATES CIVIL SERVICE COMMISSION announces an open competitive examination for aid, for men only, on December 4, 1912, at principal places in the United States. From the register of eligibles resulting from this examination certification will be made to fill vacancies as they may occur in the Bureau of Standards, Department of Commerce and Labor, at salaries of $600 to $720 a year, and vacancies in positions requiring similar qualifications.

Persons who meet the requirements and desire this examination should at once apply either to the United States Civil Service Commission, Washington, D. C., or to the secretary of the board of examiners at any examination place for Form 1312. No application will be accepted unless properly executed and filed with the Commission at Washington. In applying for this examination the title Aid (Male) should be used.

As examination papers are shipped direct from the commission to the places of examination, it is necessary that applications be received in ample time to arrange for the examination desired at the place indicated by the applicant. The commission will therefore arrange to examine any applicant whose application is received in time to permit the shipment of the necessary papers.

THE ANNUAL MEETING of the American Society of Mechanical Engineers will be held in New York, 29 West 39th St., December 3 to 6. Tuesday evening, December 3, will be devoted to the president's address by Dr. A. C. Humphreys, and to a reception to the president-elect and the retiring president. The forenoon of Wednesday will be devoted to business meeting, followed by sessions of the different sections, one on Gas Power and one on Machine Shop Practice and Textiles. The afternoon will be given to the Reports of Committees on Power Tests, Symbols, etc., and the evening to a complimentary dinner to Prof. John E. Sweet, the inventor of the straight-line engine, the Sweet balanced valve and other steam using devices, in celebration of his 80th birthday and in recognition of his services to the engineering profession.

Thursday morning sessions will be held by the sections on Railroads, Iron and Steel, and Cement Manufacture, and the afternoon will be taken up with papers on the Power Plant, and on Hydraulic and Pneumatic Apparatus. In the evening a reunion and dance will be held. Friday morning the session will be devoted to Administration and Management of Factories and Plants. Some of the papers to be presented are: The Principles of Valuing Property, Henry K. Rowell. Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Sanford A. Moss. Investigation of Efficiency of Worm Gearing for Automobile Transmission, Wm. H. Kenerson. Measurement of Air in Fan Work, Charles H. Treat. The Baltimore Sewerage Pump Valve, A. F. Nagle. The Vauclain Drill, A. C. Vauclain and Henry V. Wille. Tests of a 1000-hp., 24 Tubes High, B. & W. Boiler, B. N. Bump. The V-Notch Weir Method of Measurement, D. Robert Yarnall. Dimensions of Boiler Chimneys for Crude Oil, C. R. Weymouth. Air in Surface Condensation, George A. Orrok. The Centrifugal Blower for High Pressures, Henry F. Schmidt. Measurement of Natural Gas, Thos. R. Weymouth.

CATALOG NOTES

GENERAL ELECTRIC COMPANY has just issued an elaborate bulletin devoted to the subject of electrical equipment of iron and steel mills. The bulletin has an attractive cover, is printed in two colors, and should be of great interest to everyone connected with this industry.

PUMPING LIQUIDS by compressed air is described in Publication No. 9006 of the Westinghouse Air Brake Co., of Pittsburgh, Pa. It gives details of the method for lifting water from deep wells, and also for conveying liquids by air pressure.

A NEW CATALOG descriptive of the Anderson Model D Steam Trap has just been issued by the V. D. Anderson Co., of Cleveland, Ohio. It gives clearly all details of this trap which is described by the makers as "fool-proof."

ELEVATOR SERVICE, a pamphlet issued by the Otis Elevator Co., of New York, gives the different lubricants shown by the company for various parts of elevator lubrication, and shows a quick repair cabinet of parts the most likely to be needed in the operation of the elevator.

BULLETIN NO. 26, illustrating and describing the Economy Steam Turbine, has just been issued by the Kerr Turbine Co., Wellsville, N. Y.. Photographs of actual installations are shown, interesting steam consumption curves are given and size comparisons are made. A free copy will be mailed to anyone interested.

CONSOLIDATED ENGINEERING CO., of Chicago, Ill., has a most attractive mailing card which shows in colors different positions of the Thermo Return Valve, the views telling very plainly the story of how the valve acconplishes its work.

VARIOUS TYPES of compressors for air and gas are listed in a very complete and well illustrated pamphlet just received from the Chicago Pneumatic Tool Co.

DESCRIPTIVE LEAFLET 2480, issued by the Westinghouse Electric & Manufacturing Company covers rules for the selection of machine tool motors and gives some valuable information relative to this subject together with several application views.

DESCRIPTIVE LEAFLET 3516 also covers machine tool motor applications giving ratings and class of motors which are suitable for various types of machine tools. This is exceedingly interesting information put up in serviceable form. A diagram is also given which shows the relation between the cutting speed in feet per minute and area of cut in square inches, also the cubic inches of cut per minute.

LESCHEN'S HERCULES, published by A. Leschen & Sons Rope Co., of St. Louis, contains interesting articles on the making of manila rope and Manzanillo's deep-water harbor, with other instances of the use of Leschen's Hercules wire rope.

FROM MURPHY IRON WORKS, Detroit, we have received Catalog No. 25, of 64 pages, illustrating and describing the Murphy Automatic Furnace. Many industries are represented in the illustrations, which show various types of boilers and plants equipped with the furnaces.

THE SKETCH BOOK, issued by A. L. Ide & Sons, Springfield, Ill., describes the Ideal Corliss Valve Engine. Illustrations of the various parts are accompanied by minute explanations as to proper construction and materials. A chart shows the unbalanced and balanced positions of the steam valves during movements indicated in a motion diagram of accelerating non-releasing valve gear.

THE SPIRO TURBINE, made by the Buffalo Forge Co., has many novelties of construction and operation, all of which are shown and fully described in its new catalog.

REGRINDING, a process by which a valve is rendered practically as good as new, is the principle of the regrinding valves of the National Tube Co., described in its folder, which is also a catechism on the subject of valves.

ROSEDALE Foundry & Machine Co., of Pittsburgh, has an interesting folder describing the Holt Specialties for cleaning boiler tubes and for removing foreign matter from feed water, also the Playford chain grate stoker and the Pittsburgh shaking and dumping grate.

THE STORY of a Hole, a booklet issued by the Clement Restein Co., of Philadelphia, tells why they have left a hollow center in the new designs of Belmont packing.

MODEL C STERLING sight feed oil pump, which is something entirely new, is described in Bulletin No. 107 issued by the Sterling Machine Co., of Norwich, Conn. The pamphlet gives a sectional drawing and a full description.

BULLETIN NO. 68, entitled the Venturi Hot Water Meter, published by the Builders Iron Foundry, of Providence, R. I., explains how the meter measures the water flowing through it and the action of "the chart that tells the story."

Sparks From The Advertising Pages

"Sparks From the Advertising Pages' in Practical Engineer," writes a reader, "recalls to my mind the Mechanical Library of an engineer friend. This man is now well past the age of forty and has a complete library, which he assured me did not cost him a cent aside from the necessary postage with which to mail a request. He is one of the leaders in an Association noted for its up-to-the-minute membership.

"My friend described some of the books in his library in a chat we had recently, calling my attention first to a volume which had been published in the year 1891 and which, from its appearance seemed to have had a great deal of hard usage. On the shelves, there were several later editions of the same work. To the chance procurement of this book, when yet a young man, he ascribed the beginning of his real success.

"He speaks of it as his Engineers' Bible and tells me that he received it while firing a portable saw-mill at the very beginning of his career. It aroused in him a thirst for knowledge which it also partly supplied. Even now when he has a question of boiler capacity, efficiency or in fact any boiler problem, that book either has the answer or points out the road to it. Sometimes he has to look up a point in a later edition, but this causes him no trouble, for he is on the manufacturer's list and receives the new bulletins and pamphlets as fast as they come out.

"Numerous other catalogs, booklets and even books pertaining to different branches of stationary engineering are also on his shelves, so that he has constant and ready reference for almost any point which puzzles him.

"No doubt the value of this library would be discounted by some engineers, but to my notion it is particularly valuable because the contents of the books therein has been tempered with practice, containing but little theory. It familiarizes the operating man with the details, which often spell the difference between failure and success.

"To my way of thinking no engineer can advance very far who does not read the papers of his calling regularly. They are the lifeblood of his business and he who fails to read the advertising pages misses more than half.

"It often saves the employer much valuable time and money when installing new machinery, if his engineer has already familiarized himself with it by a careful perusal of the builder's catalog."

This appreciation of the value of the advertising pages by an engineer who collected a library by means of them, shows clearly the opportunity which is constantly lying before you—an opportunity that will broaden your sphere of usefulness.

Suppose, for instance, that your plant has ordered some new machinery—a new engine, maybe—something which requires one who is familiar with it to do the installing. If you've been a close student of the advertising section, where the new product has probably been described and illustrated—if you've been interested in it and sent for a catalog so that you could study it more closely—you can install it yourself, thus saving the expense of sending out an expert from the shop and making yourself that much more valuable to your firm.

You can never realize just how much personal benefit you will derive from close study of the advertising in Practical Engineer until you've tried it; and there's no better time to begin than right now.

PRACTICAL ENGINEER CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted under regular headings at the rates of 30 cents per line. About nine words make a line. No display type allowed, but the first three words may be set in capital letters. Minimum space sold, two lines.

Under classification, "Positions Wanted," advertisements not exceeding four lines will be inserted for subscribers once free of charge.

To insure proper classification, copy must reach this office 10 days preceding publication.

Positions Wanted

POSITION WANTED—MANAGERIAL position, with Gas Company. Can handle all ends. Mechanical and Clerical. Results guaranteed. Good references. Address Box 259, Practical Engineer, Chicago, Ill. 11-15-1

POSITION WANTED—AS ENGINEER or machinist anywhere in the south where climate is above freezing point. Can give best of references. Address Isaac B. Fairbanks, St. Louis, Mich. 11-15-1

POSITION WANTED—ENGINEER, technical graduate, 4 years experience with steam, gas, oil engines and electrical machinery. Can get results, strictly sober. Address Box 260, Practical Engineer, Chicago, Ill. 11-15-1

WANTED POSITION—AS CHIEF ENGINEER by man with over 15 years experience as Chief of large Refrigerating and electrical plant. Thoroughly competent to handle plant and men. Strictly sober. Best References and License. Address Box 261, care of Practical Engineer, Chicago, Ill. 11-15-1

POSITION WANTED—CHIEF ENGINEER wishing change 20 years experience with Corliss and automatic engines, direct and alternating current machinery. At present in charge of Lighting, heating, refrigerating, and Storage battery plant. Age 39. Address Box 262, care of Practical Engineer, Chicago, Ill. 11-15-1

POSITION WANTED—By young married man as millwright. Not afraid of work. Strictly sober and steady. Have had experience wiring lights and motors. Will go any where Northern States Preferred. Address V. G. Lomprey 1714 Jenkins St., Menominee, Mich. 11-15-1

Wanted

WANTED—SALESMAN Calling on Stationary Engineers, can double his income. Address 322 Real Estate Trust Bldg., Philadelphia, Pa. 11-15-1

WANTED—October 1st, 1912, issues of Practical Engineer. Your subscription extended 2 months for every copy of this issue sent us. Offer good until Dec. 1st, 1912. tf

WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf

WANTED EVERY ENGINEER to have our pamphlet for setting valves on Corliss Engines, simple and compound, with one or two eccentrics. Sent free. Lindstrom's Machine Works, 200 South Third St., Allentown, Pa. tf

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write Subscription Dept. They will start you in at once. tf

Help Wanted

AN EXTRAORDINARY OPPORTUNITY for party or parties with some knowledge of mechanics, not necessarily practical, with small capital. State or country rights for sale of an established patented device. Quick sale in all manufacturing districts. Exceptional profits. Address P. O. Box 489, Trenton, N. J. 10-15-2

For Sale

FOR SALE—TWO 375 H. P. Babcock & Wilcox Watertube boilers, 160 lb steam pressure, perfect condition, $1200 each. 20x48 Brown engine, $650. Duzets & Son, Hudson Terminal, New York. 11-15-1

FOR SALE—ONE ROBERTSON-Thompson indicator and reducing wheel. Used but a few times, price $30. Address Harry Fetrow, Attica, Kansas. 11-15-1

FOR SALE—New 30 H. P. Ball Automatic Horizontal engine. Lucas & Son, Bridgeport, Conn. 9-15-6

Patents and Patent Attorneys

THE PATENTOME is interesting and instructive. A liberal education in patents and how to get them. Free on request. Established 1865. Anderson & Son, Patent Solicitors, 710 G St., Washington, D. C. 11-1-2

PATENT APPLICATIONS—prepared and prosecuted for $25. Send for booklet. Harry Patton, 330 McGill Bldg., Washington, D. C. 11-15-1

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owens, 28 Owen Bldg., Washington, D. C. tf

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Building. Washington, D. C. tf

Educational and Instruction

ENGINE POCKET MANUAL, 175 pages, edited by University of Tennessee will be mailed every subscriber sending in one new subscriber to Practical Engineer. Gilt edges, bound in leather.

Miscellaneous

FOR TRADE—Stock of Groceries and Queensware acquired by Engineer in settlement of estate,—for small Compression Ice-Plant. Address Box 258, care of Practical Engineer, Chicago, Ill. 11-1-2

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